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A quarterly paper devoted to the sugar interests of Hawaii and issued by the Experiment Station for circulation among the plantations of the Hawaiian Sugar Planters' Association.

In This Issue:

Weevil Damage to Stored Rice in Hawaii:

Tests have shown unhusked or paddy rice to be highly resistant to rice weevil and other insect injury, as compared with the husked product, both polished and unpolished. In the event of periods of emergency in Hawaii when large quantities of imported or locally grown rice might be held in storage, deterioration would be least in rice held in the unhusked or paddy state.

A Refinement in the R.C.M. Determination of Phosphate in Soil:

A modified method is submitted for the determination of phosphate in soil in which a more accurate result is rendered possible by eliminating in the analytical process a number of interfering substances which may appear in the soil extract.

A Grass Mealybug Occurring on Sugar Cane:

An interesting and rare case of the grass mealybug *Antonina indica* occurring on Lahaina cane in culture pots at the Experiment Station is discussed and illustrated.

A Bufo Marinus of Exceptional Size:

A toad was recently found in Honolulu of such unusually large proportions that it is figured and described.

The Plant Food Value of Nitrogen in Filter Cake:

Repeated investigation of the plant food value of the nitrogen contained in filter cake continues to give the same answer—we are unable to secure measurable gains from, or to place any real food value on this nitrogen.

The Analysis of Plant Material for Total Nitrogen, Phosphate and Potash—An Improved and Simplified R.C.M. Procedure:

Nitrogen studies in the sugar cane plant by plantation and Experiment Station staffs have shown the value of the moisture in the specimen in making correlation comparisons.

The important relationships of potash and phosphate with the nitrogen fraction of plant materials have stimulated the development of an efficient R.C.M. procedure to make these determinations which may be used with a decided saving of time without a sacrifice of analytical accuracy.

A modified procedure is submitted which, it is believed, will embrace all of these desirable features.

Some Sugar Yield Relationships:

Studies of the effect upon sugar yields of such factors as the number of ratoons between successive plantings, of the month of starting and of harvesting the crop, and of the age of the crop at harvest, have indicated some rather definite relationships, which are shown from crop data from Waialua Agricultural Company, Ltd.

Stem Galls of Sugar Cane Induced With an Insect Extract:

The development of stem galls on cane stalks which were inoculated with an extract prepared by macerating green leafhoppers is described and illustrated. A brief discussion on auxins or growth-promoting substances which may induce stem galls is given.

The Giant African Snail Achatina fulica (Fér.) Discovered in Hawaii:

A giant African snail, notorious as a pest of vegetables and ornamentals in India, Ceylon, Malaya, Java and Borneo, where it has been introduced, has been discovered in the possession of eight different residents of Hawaii during April and May, 1938. Two lots were found on Maui and the remainder in Honolulu. They are all apparently the progeny of two introductions, totaling 10 snails, brought in by two residents in 1936. A discussion of its history and destructiveness is given.

Defining Colloidal Solutions:

In a paper presented at a meeting of the Hawaiian Section of the American Chemical Society, a brief discussion is given of some properties of colloidal solutions. Attention is called to similarities between these and true solutions.

The Introduction Into Hawaii From Mexico of Insect Parasites to Control Armyworms (1923-1924):

This article gives an account of work in Mexico by H. T. Osborn in connection with introduction of parasites for armyworms. This resulted in the establishment of two very valuable parasites—*Euplectrus platyhypenae* and *Archytas cirphis*—

which in about a year became established and soon spread throughout the Islands, and now render considerable assistance in the general control of armyworms. Other parasites were studied, the introduction of which was not successful. At the present time, with airplane service, it should be possible to introduce more of these parasites.

Introduction Into the Hawaiian Islands of Mexican Enemies of the Avocado Mealybug:

This article is an account by H. T. Osborn of his work in Mexico in 1922 in connection with the introduction into Hawaii of enemies of the avocado mealybug. The most important introduction was the little internal parasite *Pseudaphycus utilis,* which quickly became established and spread throughout the Islands, and is responsible for the continuous absence, since then, of any mealybug infestations on avocado trees.

Susceptibility of Unhusked Rice (Paddy) Versus Polished Rice to Rice Weevil Attack

By C. E. Pemberton

Stored, polished rice is subject to rapid destruction in Hawaii by certain insects, unless specially treated and then stored in clean, tight containers. Unhusked rice or paddy, although susceptible to attack by the same insects, becomes damaged very slowly. Even husked but unpolished rice shows a marked resistance to insect attack, as compared with polished rice.

A test, comparing the relative resistance of unhusked rice, husked but unpolished rice, and polished rice to rice weevil (*Calendra oryzae*) attack, was begun September 29, 1937, and completed January 14, 1938. The three lots of rice were treated as follows:

1. One hundred rice weevils were placed in a large glass jar containing three quarts of sound, polished California rice.

2. One hundred rice weevils were placed in a large glass jar containing four quarts of sound, husked but unpolished California rice.

3. One hundred rice weevils were placed in a large glass jar containing five quarts of sound, unhusked California rice (paddy).

Each of the jars was covered with a strong cloth to prevent the escape of weevils and placed in a dark room. One hundred and seven days later the jars were fumigated and the contents examined. The condition of the rice and the extent of weevil development in each lot are shown in the following tabulation:

Lot No.	Rice tested	Per cent sound grains	Number of weevils per quart of grain
1	Husked and polished	0.0	14,828
2	Husked and unpolished	76.0	1,488
3	Unhusked (paddy)	97.5	176

The test was instituted through the suggestion and help of W. J. Hartung, Executive Secretary, Diversified Crops Committee, H.S.P.A., and has bearing on the problem of rice storage in quantity during emergency periods in Hawaii.

A Refinement in the R.C.M. Determination of Phosphate in Soil*

By Francis E. Hance

This modification in analytical procedure, when substituted for that now in use, does not detract from correlation values already considered or from those to be determined. The refinement is a development resulting from research which has been in progress for some time on all R.C.M. procedures and which will continue in the future. The magnitude of correction in soil phosphate values with most soils, of course, will be found insignificant. In such cases the modification may be disregarded. However, the simplicity of the revised procedure renders the checking of the point a very easy and inexpensive matter. Interference with the estimation of phosphate in soil as occasioned by the presence of calcium, silicates, nitrates, carbonates, ferrous iron, or traces of selenium, arsenic, titanium, aluminum, or manganese are eliminated in this simple analytical revision.

A number of common or of rarer soil constituents, which may or may not be present in any given soil, react in the phosphate determination in a manner which fictitiously increases the final reading to a variable degree. To insure greater accuracy, it is recommended that the following modification of the R.C.M. determination of phosphate in soil, (a development by T. Nishimura, Assistant Chemist), be used in all laboratories, *provided* the modified procedure shows consistently a *lower,* though but slightly smaller, concentration of the nutrient than the result obtained on the same soil with the existing method.

Modified Procedure

Treat the soil by the regular procedure for the rapid estimation of phosphate in soils up to and including the close of operations in Step No. 10. Then:

1. To the concentrated hydrochloric acid-treated residue, add 20 drops of Reagent 11, P_2O_5 from a dropping bottle.
2. Evaporate to dryness as usual on an electric hot plate.
3. Add 20 drops of concentrated hydrochloric acid and evaporate again.
4. Now, add 10 drops of concentrated nitric acid and evaporate to dryness.
5. Add 10 drops of concentrated hydrochloric acid and again evaporate to dryness. Repeat the addition of concentrated hydrochloric acid and evaporate to dryness once more.
6. Proceed with Step No. 11 of the regular procedure as usual and continue with the rapid estimation of phosphate in soil.

Interfering substances are volatilized or rendered impotent by the modified treatment. Reagent 11, P_2O_5 consists of a mixture of hydrobromic and hydrochloric acids. The appearance of a reddish coloration in the residue after the bromine treatment may be expected. It will be dissipated, however, by the subsequent nitric acid digestion.

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* A modification of the standard procedure for the rapid determination of phosphate in soil, appearing in *Soil and Plant Material Analyses by Rapid Chemical Methods,* The Hawaiian Planters' Record, 40: 189-299, 1936.

Occurrence of the Grass Mealybug *Antonina indica* Green on Sugar Cane

By C. E. Pemberton

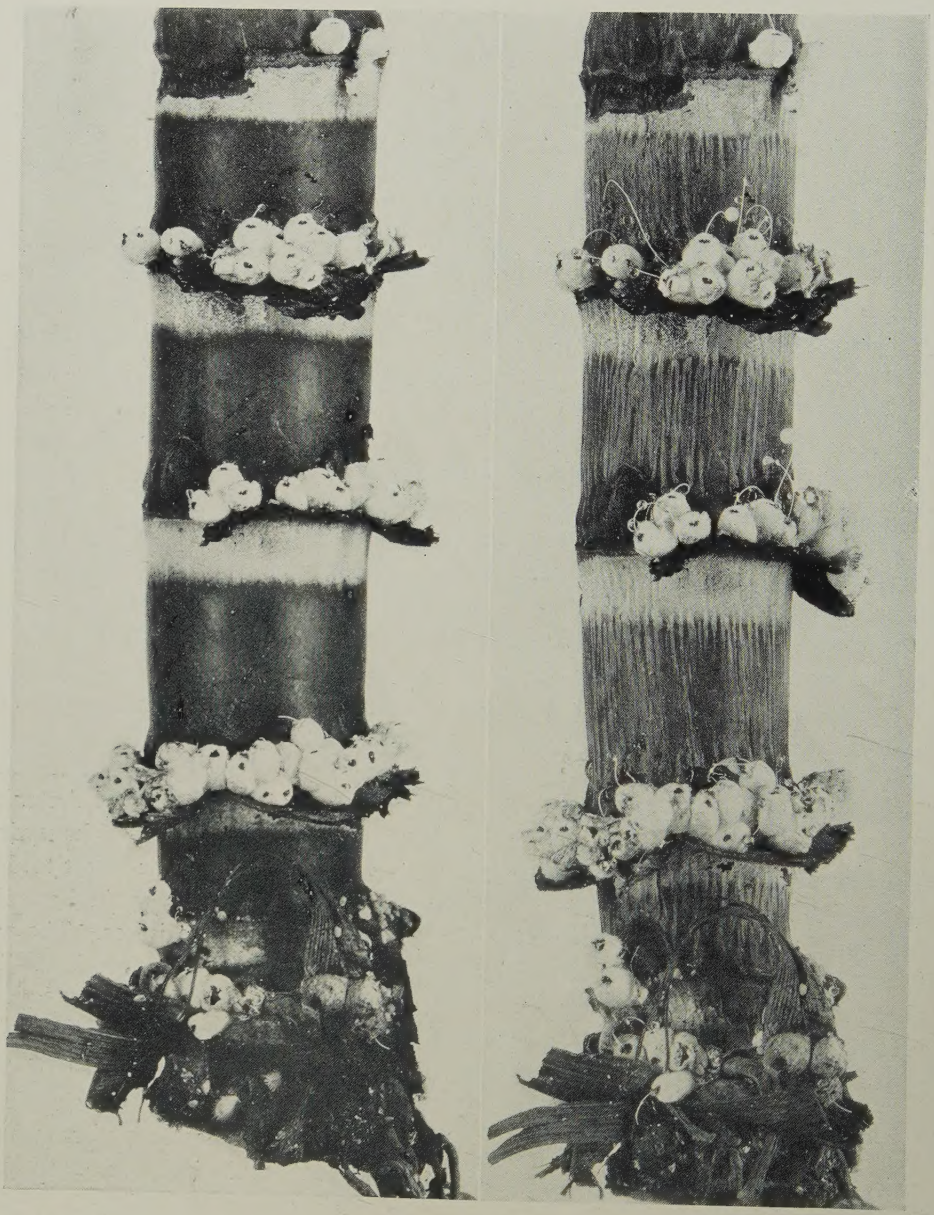
The immigrant mealybug *Antonina indica* Green, which occurs in Hawaii mostly on the nodes of Bermuda Grass *Cynodon dactylon,* has on rare occasions been seen on sugar cane. In September 1931, F. X. Williams reported finding a species of Antonina on some sugar cane growing in pots at Mapulehu, Molokai. This was probably *A. indica.* On October 6, 1932, R. H. Van Zwaluwenburg found this mealybug on aerial roots of Lahaina cane growing on isolated tables at the Pathology Plot of the Experiment Station on Alexander Street, Honolulu. O. H. Swezey identified the species as *Antonina indica.*

It is of interest to again record the recurrence of this mealybug in fair quantity on Lahaina cane during the month of January 1938. The mealybugs were found by J. P. Martin massed on the nodes of this cane, which he had growing in sand cultures in pots at the Experiment Station. The pots containing the cane were raised several inches above the ground and were resting on a low wooden platform outdoors. The accompanying photographs, taken by W. Twigg-Smith, clearly show the general appearance of the species as it clusters about the root band on the lower nodes of the Lahaina stalk.

In the photo on the right a short white thread can be seen extending from the posterior end of many of the mealybugs. This thread is a hollow, tubular, wax filament through which the insect exudes a clear, honey-like secretion, technically known as honeydew. This single thread is characteristic of species of Antonina. At the tip of some of the threads in the photo can be seen a globule of honeydew. This tubular thread seems to render a useful service in enabling the insect to drop the sticky honeydew away from its immovable body and thus avoid becoming smothered and otherwise hampered by its own viscous, adhesive juices. The wax thread is brittle and when broken off is completely reformed within a few days. The photo on the left shows the mealybugs with the filaments mostly broken off by ants before the cane was cut. The same piece of cane is again pictured on the right a few days later after having been isolated from ants long enough to permit the elaboration of the wax tube.

It is curious that on the few occasions when this mealybug has been seen on sugar cane, the latter was growing in pots off the ground and that the insect seems to favor Lahaina cane.

This mealybug is never likely to be a pest on sugar cane in Hawaii. It was first recorded in the islands by Jacob Kotinsky in the *Proceedings of the Hawaiian Entomological Society* for May 1910. It has undoubtedly been in the islands over thirty years. One or more parasites attack it and are moderately effective.



Antonina indica on Lahaina cane.

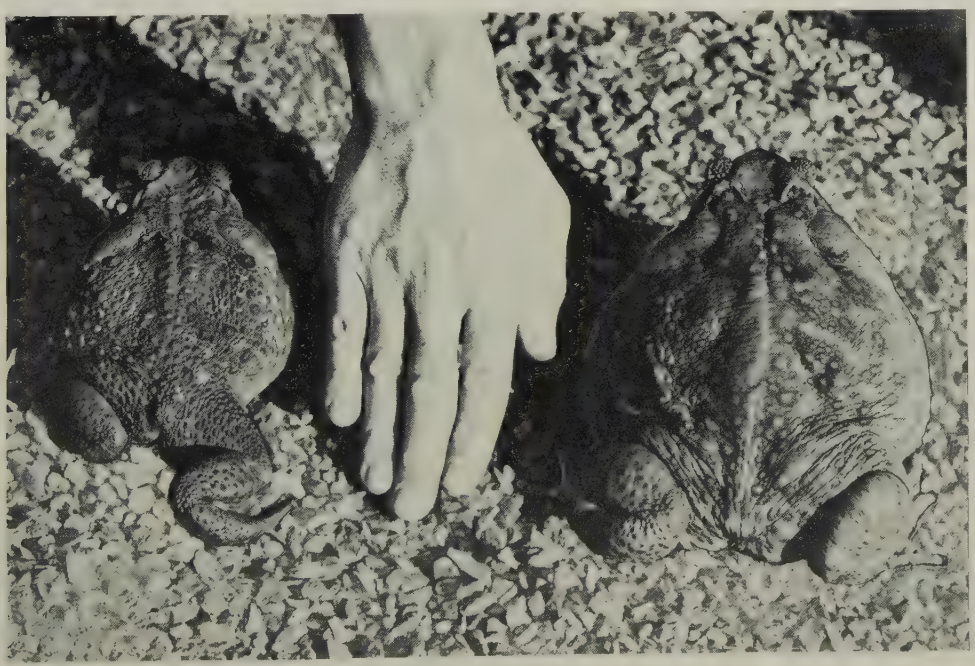
A *Bufo Marinus* of Exceptional Size

By F. A. Bianchi

Although surprisingly large individuals of *Bufo marinus* are occasionally found in other countries, and the writer himself observed one such in Guatemala, it was not suspected heretofore that any Bufos in the Hawaiian islands had attained the size of the larger specimen shown in the accompanying photographs. By the usual standards of our toad population the smaller specimen pictured is of fair size; being one of a lot that has been kept under observation and regularly fed since 1933, it may be presumed to be, if anything, above the average. By comparison with the larger specimen shown, however, the ordinary toad is a mere dwarf.

The giant is a female. Captured by the writer on Poki Avenue one block southeast of the Kapahulu Fire Station, it was found on the night of February 7, 1938, and is presumed to be an unusually old specimen. In addition to its unprecedented size, the pronounced smoothness and somewhat distinctive coloration of its skin lead to the belief that this toad may be one of the 149 original individuals introduced by C. E. Pemberton from Puerto Rico in 1932. On the other hand, since there is no certain way of judging a toad's age, this giant may be no older than any other of our toads of average size, and in that case its unusual development remains to be explained. Two possible explanations that naturally suggest themselves are a physiological abnormality such as occasionally causes giantism in other animals, or a very rare combination of circumstances that may have provided this toad with a uniquely favorable environment.

Whereas the common toads of our gardens seldom weigh as much as one pound, the present specimen weighs 2 pounds 9 ounces, has a body length of 7⅜ inches, a width of $6\,^{5}/_{16}$ inches, and a girth of 15½ inches around the widest part of the abdomen.



A giant *Bufo marinus* shown in comparison with a normal adult and an average human hand.

A giant *Bufo marinus* with a body length of 7⅜ inches, exclusive of the legs.

The Plant Food Value of Nitrogen in Filter Cake

By R. J. Borden

Continuing our attempt to determine the separate plant food values of sugar mill by-products, the investigation which is discussed hereafter has been concerned with the specific plant food value of the nitrogen content of filter cake.

In previous studies* of this question, we have been unable to secure any clearly indicated nitrogen response with a crop planted on soil in which filter cake had been incorporated. It has been suggested that these results were perhaps due to the fact that our crops were planted too soon after applying the filter cake, and that a longer period of fallow, between the mixing into the soil of this carbonaceous material (C/N ratio 26:1) and of planting the crop, would result in its more complete decomposition, with subsequent release of its nitrogen content for the growing plants. The present test was therefore planned with this thought in mind.

The soil used was a heavy, clay-like alluvium from the low-lying area (Yamada field) at our Waipio substation. It was neutral in reaction (pH 6.9), deficient in available nitrogen but well supplied with both phosphate and potash. In its natural state, this soil is sticky, tight, and poorly drained, hence the various applications of filter cake temporarily improved its physical condition.

The Plan:

After a thorough mixing, the soil was divided into three principal series and one of these into a subseries, for further specific plant food treatments. (1) In Series I, both the filter cake and the commercial nitrogen fertilizer were added to the soil at the beginning of a six-month period of fallow. (2) In Series II, only the filter cake was added to the soil at the beginning of the six-month fallow period; the nitrogen fertilizer was not added until the end of the fallow at the time the crop was planted. Supplementing four of the treatments in Series II, a subseries was included wherein the six-month fallow periods were modified as follows: to "C"—one month of fallow before adding the filter cake to the soil followed by five months of fallow after it was incorporated; to "B"—two months of fallow without filter cake, followed by four months of fallow after its addition; to "A"—three months of fallow without the cake, followed by three months of fallow after it was added. (3) In Series III, the soil was fallowed without either filter cake or nitrogen for the entire six months, both of these materials being applied only immediately before planting.

Fourteen treatments were included (in duplicate) in Series I, II and III but only Treatments 7, 8, 9, and 10 were used in the subseries A, B, and C. These treatments were as follows:

* Some Plant Food Values in Molasses and Filter Cake. The Hawaiian Planters' Record, 39:180-190, 1935.

Treatment No.	Tons filter cake per acre (wet basis—75% water)	Pounds nitrogen per acre—From filter cake	Pounds nitrogen per acre—From fertilizer	Pounds nitrogen per acre—Total
1	0	0	0	0
2	11	100	0	100
3	0	0	100	100
4	22	200	0	200
5	11	100	100	200
6	0	0	200	200
7	33	300	0	300
8	22	200	100	300
9	11	100	200	300
10	0	0	300	300
11	33	300	100	400
12	22	200	200	400
13	11	100	300	400
14	0	0	400	400

To avoid any possible deficiency, both phosphoric acid and potash were supplied and mixed into the soil of all pots alike, at the beginning of the six-month period of fallow.

During the entire fallow period, the soils (which were all potted) were kept under conditions which should have been favorable for maximum soil-microbial activity. At intervals of two weeks, the soil of each pot was dumped into a clean mixing bowl, thoroughly turned over, and returned to its container. At these times, a soil sample was taken for an analysis (by R.C.M.) of its available nitrogen content.

The pots were all planted with Panicum grass in May and thereafter given identical care and treatment. The first crop was harvested in September, 16 weeks after starting. The plants in all pots had been "yellow" and had made no apparent growth for fully four weeks previous to harvest; thus it was believed that they had used up all available nitrogen. After being harvested, the stubble (except for the subseries) was ratooned for a second crop. The absence of any residual nitrogen effects from the original filter cake applications was evident from the very start of this ratoon or second crop.

Discussion of the Results:

The results can perhaps best be shown on and discussed from the graphs. The dry weights of material harvested are summarized in Table II. The photograph (Fig. 1) shows the plants in Series II at the time of their harvest.

The probable fate of the available nitrogen supply in a fallowed soil which has been supplied with filter cake is clearly indicated in Fig. 2. At the time of potting (November 2) this soil contained 61 pounds of water-soluble nitrogen per acre-foot. In the absence of filter cake, this natural nitrogen supply increased with some regularity up to 137 pounds in January, then for some unknown reason, made a sharp decline in February, but increased somewhat irregularly thereafter, but at no time did it drop back to its starting point.

In contrast to this soil without filter cake, we note that in the four cases following the addition of filter cake, averaging 22 tons per acre and hence containing 200 pounds of nitrogen, the available nitrogen content of the soil which at the time of

Fig. 1.

Pot Nos.	Treatments
914-915	No filter cake or nitrogen fertilizer.
916-917	100 lb N from 11 tons filter cake only.
918-919	100 lb N from fertilizer only.
920-921	200 lb N from 22 tons filter cake only.
922-923	200 lb N; 100 from cake and 100 from fertilizer.
924-925	200 lb N from fertilizer only.
926-927	300 lb N from 33 tons filter cake only.
928-929	300 lb N; 200 from cake and 100 from fertilizer.
930-931	300 lb N; 100 from cake and 200 from fertilizer.
932-933	300 lb N from fertilizer only.
934-935	400 lb N; 300 from cake and 100 from fertilizer.
936-937	400 lb N; 200 from cake and 200 from fertilizer.
938-939	400 lb N; 100 from cake and 300 from fertilizer.
940-941	400 lb N from fertilizer only.

Status of Available Nitrogen in Fallow Soils (of Series II) Without and Following the Incorporation of Filter Cake

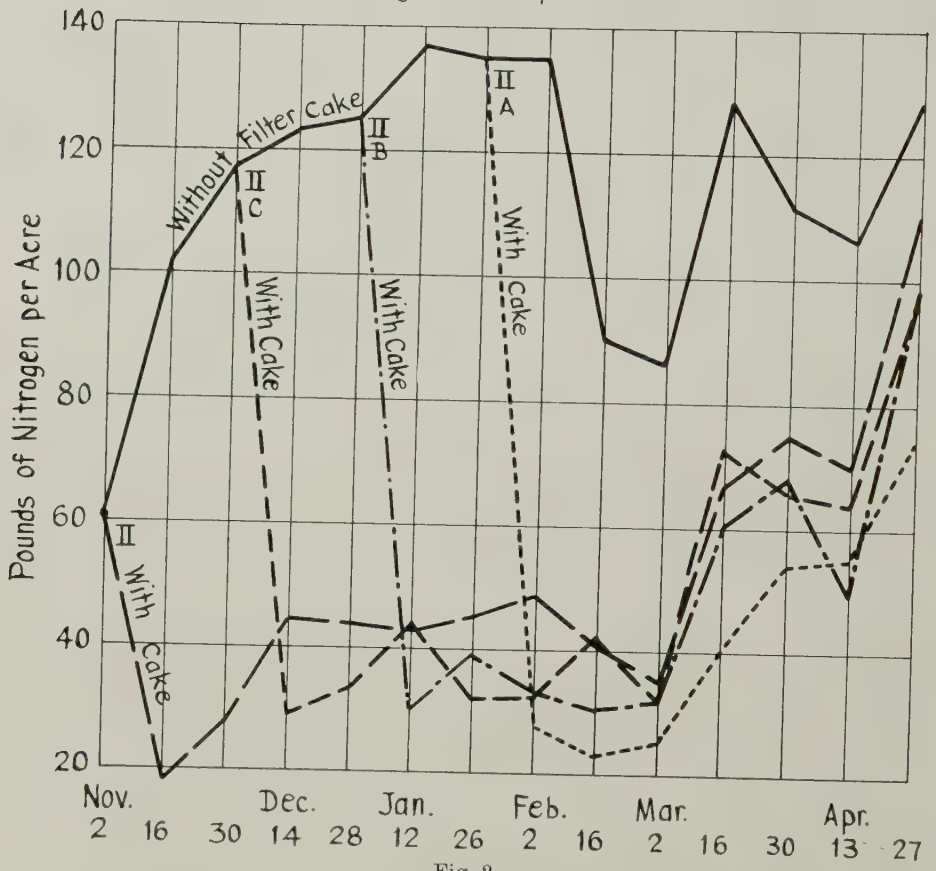
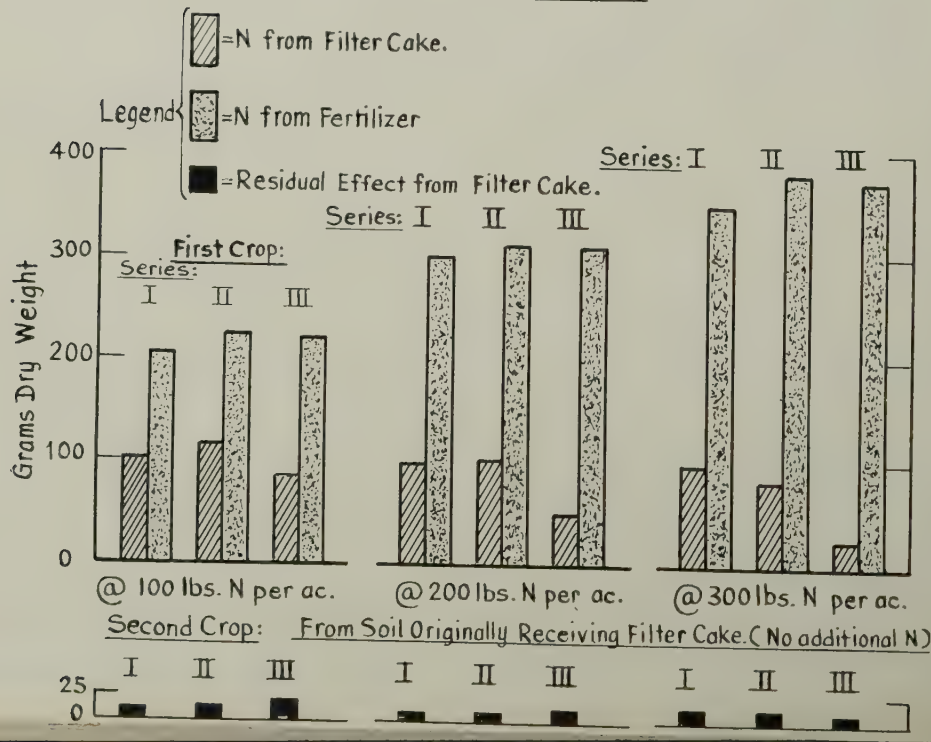


Fig. 2.

Comparative Yields from Equivalent Amounts of Nitrogen Supplied in Filter Cake and in Commercial Fertilizer at Various Rates per Acre



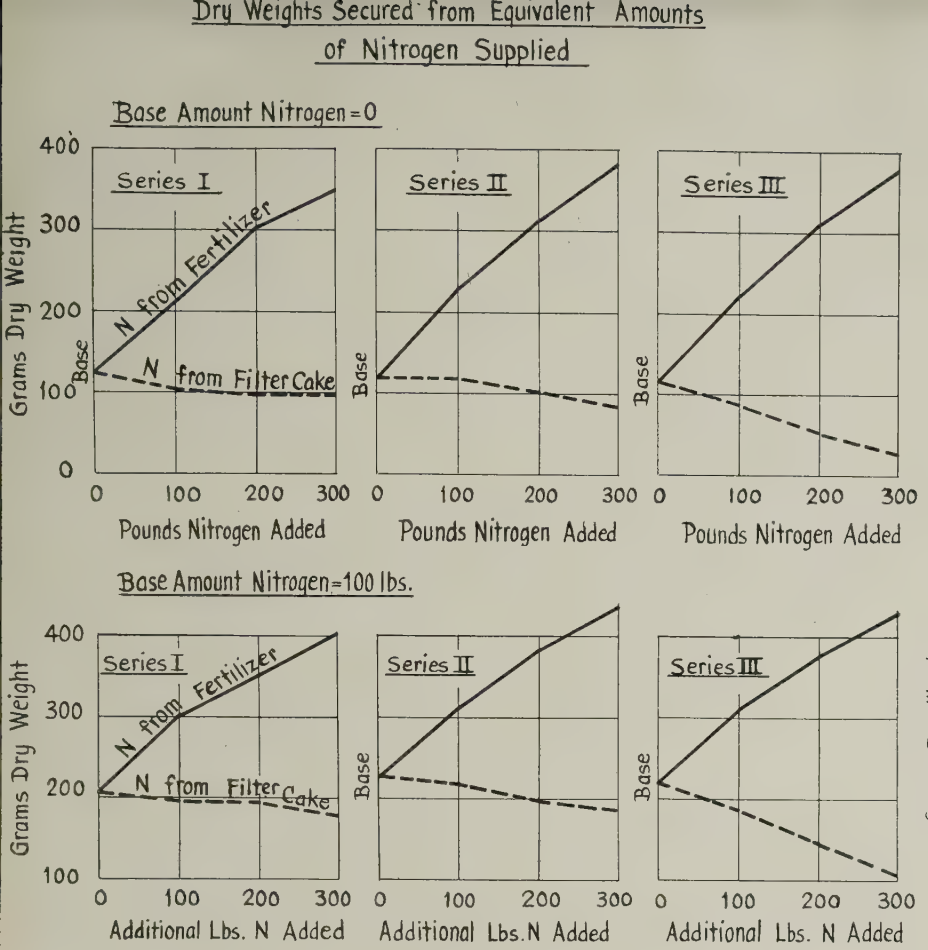

Dry Weights Secured from Equivalent Amounts of Nitrogen Supplied
Base Amount Nitrogen = 0
Series I
Series II
Series III
N from Fertilizer
N from Filter Cake
Base
Grams Dry Weight
Pounds Nitrogen Added
Base Amount Nitrogen = 100 lbs.
Additional Lbs. N Added

Fig. 4.

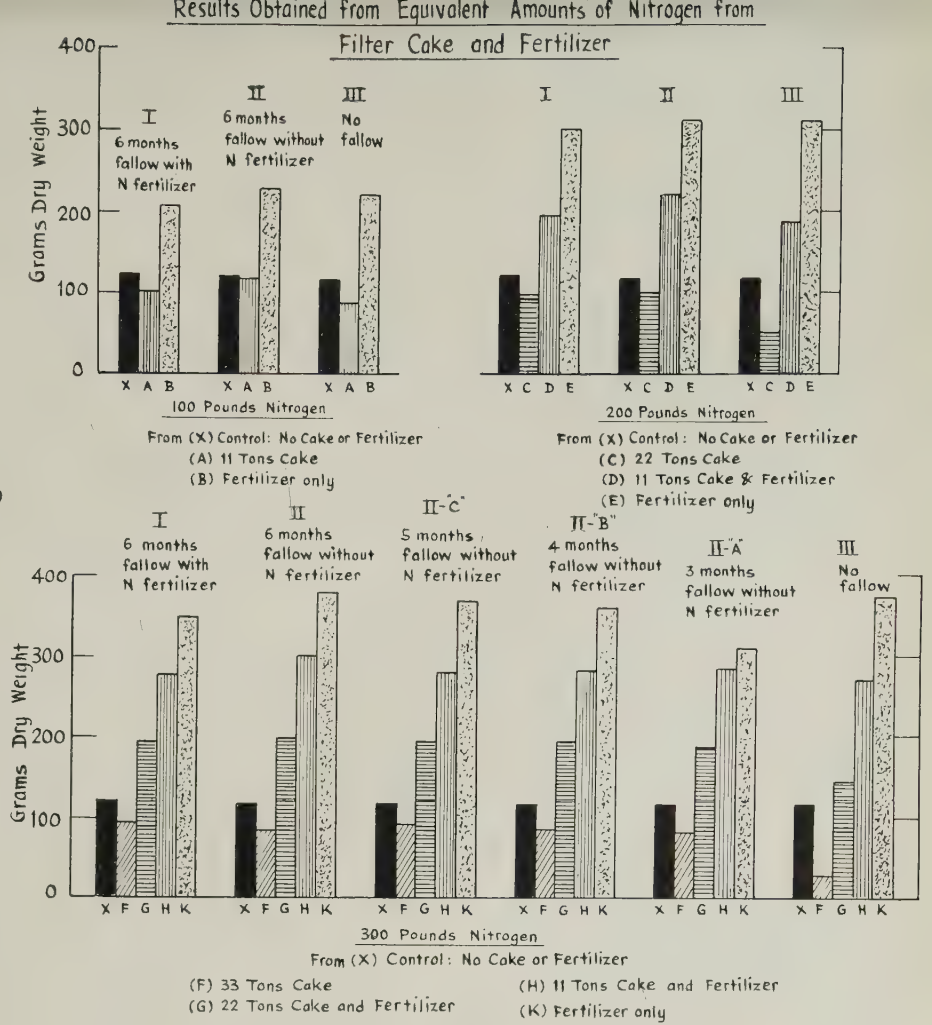

Results Obtained from Equivalent Amounts of Nitrogen from Filter Cake and Fertilizer
I 6 months fallow with N fertilizer
II 6 months fallow without N fertilizer
III No fallow
Grams Dry Weight
100 Pounds Nitrogen
From (X) Control: No Cake or Fertilizer
(A) 11 Tons Cake
(B) Fertilizer only
200 Pounds Nitrogen
From (X) Control: No Cake or Fertilizer
(C) 22 Tons Cake
(D) 11 Tons Cake & Fertilizer
(E) Fertilizer only
II-"C" 5 months fallow without N fertilizer
II-"B" 4 months fallow without N fertilizer
II-"A" 3 months fallow without N fertilizer
300 Pounds Nitrogen
From (X) Control: No Cake or Fertilizer
(F) 33 Tons Cake
(G) 22 Tons Cake and Fertilizer
(H) 11 Tons Cake and Fertilizer
(K) Fertilizer only

Fig. 5.

incorporation averaged 61, 117, 125 and 135 pounds respectively, was abruptly reduced (within two weeks) to very low levels: 18, 29, 30, and 28 pounds, and remained close to 40 pounds until March. At this time, its nitrogen content also began to increase, and at the end of the six months of fallow, it was on its way to catch up with the nitrogen content of the soil which had not received the filter cake. Thus at the time the crop was planted, the maximum difference between the soils-with-cake and soils-without-cake was only 54 pounds of soluble nitrogen, and there is an indication that such difference was progressively less for those soils which had received their filter cake applications earlier in the fallow period. But it is also true that the nitrogen content of the filter cake, even when it had been in the soil for six months, had not been made available. Furthermore, soil samples taken from each pot after the crop was harvested showed a complete absence of water-soluble nitrogen, and thus verified the foliary diagnosis which had indicated that the supply of available nitrogen had all been used.

It is believed, therefore, that the final answer to our question will be found in the total dry weights produced by soils to which our comparative treatments have been applied. Thus we look at Figs. 3, 4, and 5 with considerable interest.

Fig. 3 very definitely shows that when the nitrogen in filter cake and in commercial fertilizer is compared pound for pound, the filter cake nitrogen is greatly inferior in its availability to a growing crop. Also, whereas increased amounts of nitrogen from fertilizer gave increasingly larger yields, this was not the effect when the same nitrogen increases were supplied from filter cake; in fact, the tendency was for slightly lower yields from the increased amounts of nitrogen supplied in the heavier applications of filter cake. Even a second cropping of this soil failed to show the desired residual effect or to indicate further availability of the nitrogen supplied with the filter cake applications which preceded the first crop.

The first glance at the "curves" in Fig. 4 will also show that the nitrogen added in the filter cake has not been made available to the first crop. Not only this, but it is apparent that the applications of filter cake have actually removed some of the natural soil nitrogen supply to an extent which has resulted in depressed yields. This fact is more apparent in Series III, wherein planting followed immediately after the application of the filter cake to the soil, than in Series I and II which had had the filter cake incorporated for a period of six months before planting.

A similar conclusion must also be drawn from Fig. 5. In every instance, the addition of filter cake resulted in a decreased dry weight for the crop which followed. Mixtures of filter cake with nitrogen fertilizer produced yields which were the equivalents only of the nitrogen fertilizer alone. There is no evidence that the nitrogen in the filter cake was made available for this crop.

The loss due to the addition of 100 pounds of nitrogen from filter cake and the comparative gains which are due to additions of equivalent amounts of nitrogen from commercial fertilizer are given in Table I. These applications of nitrogen from filter cake, to soils which had been built up to basal amounts of 0, 100, 200 and 300 pounds of nitrogen respectively, always resulted in losses in dry weight which were generally significant amounts. Conversely the equivalent nitrogen applications from fertilizer gave consistent and always significant gains. The average gains and losses for the three series indicate that the loss for the filter cake application (11 tons per acre containing 100 pounds N), regardless of the basic amount of nitrogen which

it supplemented, was quite similar. On the other hand, the gains for the nitrogen fertilizer applications (at 100 pounds per acre) diminished somewhat according to the "law of diminishing returns" as the basic amount of nitrogen increased.

These results force us to believe that we cannot expect to secure tangible benefits from, or place any real plant food value on, the nitrogen that is contained in heavy applications of filter cake.

TABLE I

GAINS OR LOSSES (GRAMS DRY WEIGHT) FROM THE APPLICATION OF 100 POUNDS OF NITROGEN FROM FILTER CAKE OR FERTILIZER

Basal amts. in soil (lb N)	Series I — 100 lb N added		Series II — 100 lb N added		Series III — 100 lb N added		Avg. 3 Series — 100 lb N	
	from cake	from fertilizer	from cake	from fertilizer	from cake	from fertilizer	from cake	from fertilizer
0	—19	+ 84	0	+110	—29	+105	—16	+100
100	— 9	+ 94	— 7	+ 86	—35	+ 88	—17	+ 89
200	—13	+ 47	—10	+ 70	—38	+ 65	—20	+ 61
300	— 8*	+ 54	—16	+ 53	—23	+ 53	—16	+ 53

* Possibly due to chance (less than 2 x SEd).

TABLE II

SUMMARY OF DRY WEIGHTS SECURED FROM 14 TREATMENTS IN SERIES INDICATED

Treatment No.	Original treatments added — Tons cake	Original treatments added — lb N from fertilizer	Series I	Series II	Series II "A"	Series II "B"	Series II "C"	Series III
1	0	0	122.8∓ .8	117.2∓ .2				116.6∓ .9
2	11	0	103.6∓1.4	117.7∓ .7				87.1∓1.4
3	0	100	206.9∓3.3	227.2∓ .2				221.6∓3.5
4	22	0	98.6∓2.3	102.9∓6.3				51.7∓1.7
5	11	100	197.7∓1.6	220.8∓1.9				186.8∓1.0
6	0	200	301.4∓2.4	312.9∓1.9				310.0∓1.0
7	33	0	98.2∓4.0	84.3∓4.2	81.1∓ .2	85.4∓2.0	91.3∓ .2	27.8∓4.0
8	22	100	195.0∓ .5	199.3∓2.2	187.7∓2.7	195.4∓2.5	194.6∓ .5	144.5∓3.8
9	11	200	278.1∓2.7	302.0∓ .7	284.4∓ .7	283.9∓1.9	282.3∓3.1	272.3∓1.7
10	0	300	348.7∓3.4	382.0∓1.9	310.8∓1.2	360.4∓2.7	368.4∓4.3	374.6∓3.9
11	33	100	177.3∓1.0	187.7∓1.0				109.8∓2.5
12	22	200	271.9∓1.9	289.2∓1.7				233.0∓2.2
13	11	300	340.1∓3.1	366.3∓2.7				351.2∓1.7
14	0	400	403.2∓3.2	434.6∓5.5				428.4∓3.0
1	0	0	4.1*	8.3*				10.0*
2	11	0	10.3*	8.2*				14.1*
4	22	0	13.5*	9.5*				14.6*
7	33	0	19.0*	11.2*				10.1*

* Residual effect from second cropping without additional nitrogen, but refertilized with P_2O_5 and K_2O.

The Analysis of Plant Material for Total Nitrogen, Phosphate and Potash—An Improved and Simplified R.C.M. Procedure*

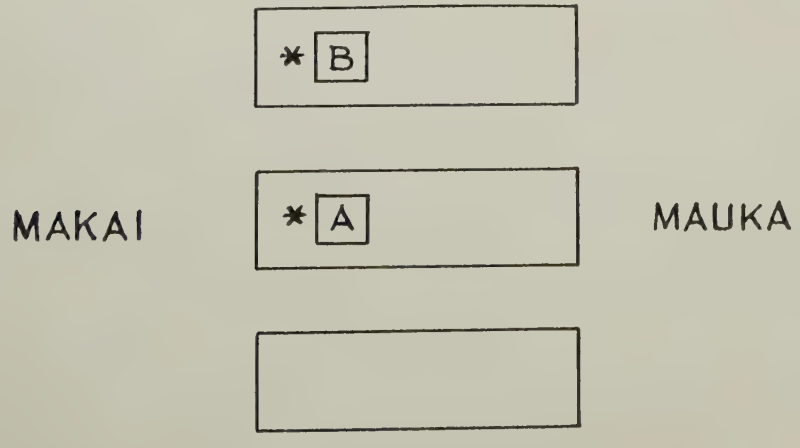
By T. Nishimura and Francis E. Hance

In any type of chemical analysis of plant material the matter of moisture in the specimen must be considered and the method of analysis and interpretation of data should be weighed accordingly.

It is an accepted belief that physiological and chemical reactions in green plant tissue are altered in the process of drying. It is necessary, therefore, to extract and separate various fugitive forms of nitrogen as rapidly as possible under controlled manipulation from the fresh green specimen prior to chemical analysis. Moisture content of a duplicate specimen may be determined separately, and may be used thereafter to refer the nitrogen findings to a dry-weight basis.

In making a total nitrogen determination in the same material the green weight of the sample from living tissue may vary in moisture percentage from hour to hour while the actual total nitrogen value may remain stationary for several hours. This fact was clearly demonstrated by Paul I. Fagan, Jr. in a study made on Project A 105.117, under the direction of L. R. Smith, where artificial rain was employed to influence the ratio of moisture to dry matter in one set of growing plants. Mr. Fagan's progress report on the study is quoted below:

Object: The effect of rain on the total nitrogen percentage in green-leaf material.
Equipment: Ticket punch for sampling. R.C.M. for total nitrogen, hose for watering cane.
Location and material used: Field 19, Makiki; cane, 31-1389.



* A modification of the standard procedures for the rapid determination of total nitrogen, phosphate and potash in cane plant material appearing in *Soil and Plant Material Analyses by Rapid Chemical Methods—II,* The Hawaiian Planters' Record, 41: 135-186, 1937.

Procedure: Sample I, taken January 14, 1938. Selected twelve stalks in both *A and *B from which six samples were taken (three from A and three from B). Each sample contained 72 disks, or six from each stalk, or 2 disks from the third, fourth and fifth leaves of each stalk. From 10:30 a. m. to 11:30 a. m. water (artificial rain) was sprayed from above on Plot A.

Sample II, taken at 11:30 a. m. Same as Sample I, except for the different conditions in Plot A. Samples were taken at once to the R.C.M. Laboratory where they were weighed and analyzed.

Detailed results:

Total N in Leaf			
Sample I		Sample II	
A	B	A	B
.52 ± .01	.51 ± .01	.42 ± .02	.51 ± .02

Conclusion: After rain, the total nitrogen in the cane leaf, as shown by R.C.M. analyses, is significantly lower.

It is obvious, therefore, that had the four analyses been made on the individual group of 72 punch specimens each, regardless of their respective weights, the data would have been entirely comparable.

The analytical procedure described below is a modification and simplification of the R.C.M. analyses of plant material. The older method was developed in 1932 at the instance of H. P. Agee, former Director of this Experiment Station. Mr. Agee described the objectives of his proposal for plant material research in a paper entitled *The Sugar Planter Looks at Botany,* submitted at the 52nd Annual Meeting of The Hawaiian Sugar Planters' Association. The revised procedure has been adjusted to allow the research worker full opportunity to employ moisture relationships appropriately with the objective of his study.

The method is applicable to the analysis of any organic material. However, it was developed specifically for the study of fresh sugar cane specimens. The terminology used in the text refers to cane leaf-punch disks.

Modified Procedure

The following method enables the operator to make determinations of total nitrogen, phosphate and potash in cane plant material *after a single preliminary treatment.*

Treatment of Sample:

1. Obtain representative *green* cane leaf material weighing exactly 0.90 gram, (approximately equivalent to 216-225 leaf punches).
2. Transfer material to a 300-cc. Kjeldahl flask.
   a. Drop two porous granules into the flask.
   b. Add ⅓ spoonful (0.5 gram) of sodium sulfate, C.P. (Na_2SO_4).
   c. Introduce 4 cc. Reagent 15, Total N, with the special pipette.
3. Place on a Type "H" electric heater and digest for 45 minutes.
4. Cool and transfer contents into a 100-cc. volumetric flask. Make up to 100 cc. with Reagent 18, Total N.

Moisture Determination:

Investigators desiring to obtain results on a moisture-free basis should proceed as follows:

1. Obtain samples of representative (or composite) *green* cane leaf material in conjunction with the sampling for total nitrogen, phosphate and potash analyses.
2. Weigh the green-leaf material and record the weights.
3. Dry for 3-5 hours in an electric oven at 100° C.
4. Cool dried material in an air-tight container and weigh again.
5. Obtain the percentage moisture, as follows:
   Weight of green (fresh) material, minus weight of dried material = weight of moisture (H_2O)

$$\frac{\text{Weight of moisture} \times 100}{\text{Weight of green material}} = \% \text{ moisture}$$

6. Refer the percentage moisture to the "Moisture Correction Table" and obtain its factor.
7. To obtain results on a moisture-free basis, use the formula:
   % on green (fresh) material × factor = % on moisture-free basis.

MOISTURE CORRECTION TABLE

% Moisture	Factor	% Moisture	Factor
60	2.50	73	3.70
61	2.56	74	3.85
62	2.63	75	4.00
63	2.70	76	4.17
64	2.78	77	4.35
65	2.86	78	4.54
66	2.94	79	4.76
67	3.03	80	5.00
68	3.12	81	5.26
69	3.23	82	5.56
70	3.33	83	5.88
71	3.45	84	6.25
72	3.57	85	6.67

Total Nitrogen in Cane Leaf Material:

1. Pipette 25 cc. of solution from Step No. 4, under "Treatment of Sample," into a 300-cc. Kjeldahl flask.

a. Add 75 cc. of Reagent 18, Total N to bring volume to 100 cc.

b. Add 20 cc. of Reagent 17, Total N and immediately place on a heater, together with distillation assembly (as in the determination of Total N in cane juice).

2. Pipette 5 cc. of the distillate into a 50-cc. beaker. Add 25 cc. of Reagent 18, Total N and mix.

3. Pipette 5 cc. of the diluted solution into a comparison vial. Add 1 cc. of Reagent 6, N with the special pipette. Stopper and let stand 1 minute.

4. Compare on the illuminator with the ammonia nitrogen-in-soil color standards. In comparing colors, select an aliquot (5 cc. to 2 cc.) which will produce a color intensity matching almost exactly that of any standard color tube, preferably between Nos. 3 to 6, inclusive.

5. Refer to the data sheet for percentages of nitrogen.

PERCENTAGE TOTAL NITROGEN (WET BASIS) IN GREEN CANE LEAF MATERIAL

(To obtain results on moisture-free basis, refer to Moisture Correction Table)

Aliquots	Standard tube numbers						
cc.	2	3	4	5	6	7	8
5.0	.16	.27	.37	.48	.64	.80	1.07
4.5	.18	.30	.41	.53	.71	.89	1.19
4.0	.20	.34	.46	.60	.80	1.00	1.34
3.5	.23	.39	.53	.69	.91	1.14	1.53
3.0	.27	.45	.62	.80	1.07	1.33	1.78
2.5	.32	.54	.74	.96	1.28	1.60	2.14
2.0	.40	.68	.93	1.20	1.60	2.00	2.68

Potash in Cane Leaf Material:

1. Pipette 25 cc. of solution from Step No. 4, under "Treatment of Sample," into a 100-cc. beaker.

2. Place the beaker on an electric hot plate at full heat and evaporate to dryness, or until the evolution of fumes has practically ceased.

3. Cool slightly and add 2 cc. of 1 Normal sodium hydroxide (NaOH). Evaporate slowly to dryness on an electric hot plate at *low heat. Avoid spattering.*

4. Add 5 cc. of Reagent 1, K_2O to the contents of the beaker and shake well. Filter through Munktell No. 3, 7-cm. filter paper.

5. Take aliquots of 1.0, 0.9, 0.8 cc., etc., and make readings, using the technic involved in the usual R.C.M. for potash in soils or in juices.

6. Refer to Table I for the percentages of potash.

7. For samples which are expected to show amounts of potash greater than 0.30 per cent, use 10 cc. of Reagent 1, K_2O (instead of 5 cc.) in Step No. 4.

8. Then proceed as usual and refer to Table II for the percentages of potash.

PERCENTAGE POTASH (WET BASIS) IN GREEN CANE LEAF MATERIAL

(To obtain results on moisture-free basis, refer to Moisture Correction Table)

TABLE I

	Aliquots taken (extracted with 5 cc. Reagent 1, K_2O)									
Readings	1 cc.	.9 cc.	.8 cc.	.7 cc.	.6 cc.	.5 cc.	.45 cc.	.40 cc.	.35 cc.	.30 cc.	.20 cc.
2	.17	.18	.21	.24	.28	.33	.37	.42	.48	.56	.84
3	.19	.21	.24	.27	.32	.38	.42	.47	.54	.63	.95

TABLE II

	Aliquots taken (extracted with 10 cc. Reagent 1, K_2O)										
Readings	1 cc.	.95 cc.	.90 cc.	.85 cc.	.80 cc.	.75 cc.	.70 cc.	.65 cc.	.60 cc.	.55 cc.	.50 cc.
2	.33	.35	.37	.39	.42	.44	.48	.51	.56	.61	.67
3	.38	.39	.42	.44	.47	.50	.54	.58	.63	.69	.75

Phosphate in Cane Leaf Material:

1. Pipette 20 cc. of solution from Step No. 4, under "Treatment of Sample," into a 100-cc. beaker.

2. Add sufficient ammonium hydroxide (NH_4OH), Reagent 9, N, to neutralize the acid—about 2 cc. (Use litmus paper, if necessary.)

3. Evaporate to dryness on an electric hot plate at low heat. *Avoid spattering.*

4. Add 10 cc. of Reagent 4, P_2O_5 and mix well.

5. Using a 5-cc. Mohr pipette, take a 4.0-cc. aliquot from the above solution and make it up to 8 cc. with Reagent 4, P_2O_5 in a phosphate vial. (For any subsequent aliquot taken, always bring volume up to 8 cc. with Reagent 4, P_2O_5.)

6. Add stannous chloride solution and compare with cane juice standards, employing the usual R.C.M. technic.

7. In case the intensity of the color developed does not closely match that of the standard tube, repeat Step No. 5, using different aliquots (4.75 cc. to 3 cc.) until an almost exact match is obtained.

8. Refer to the table for the percentage of phosphate.

PERCENTAGE PHOSPHATE (WET BASIS) IN GREEN CANE LEAF MATERIAL

(To obtain results on moisture-free basis, refer to Moisture Correction Table)

Aliquots	Standard tube numbers							
cc.	1	2	3	4	5	6	7	8
5.00	.035	.053	.071	.089	.107	.124	.142	.160
4.75	.037	.056	.075	.094	.112	.131	.150	.168
4.50	.039	.059	.079	.099	.118	.138	.158	.178
4.25	.042	.063	.084	.105	.125	.146	.167	.188
4.00	.044	.067	.089	.111	.133	.156	.178	.200
3.75	.047	.071	.095	.118	.142	.166	.190	.213
3.50	.051	.076	.102	.127	.152	.178	.203	.229
3.25	.055	.082	.109	.137	.164	.191	.219	.246
3.00	.059	.089	.119	.148	.178	.207	.237	.267

Some Sugar Yield Relationships

By R. J. Borden

The opportunity to determine certain interesting relationships which might be concerned with sugar yields was recently offered when ten years of field records from the Waialua Agricultural Company were made available for study. The results of four questions which were investigated are hereafter presented graphically with short comments and discussion. The study was confined to fields cropped with the cane variety H 109, and all such fields were included.

1. Relation Between Sugar Yield and the Crop of a Field Cycle:

The ability of H 109 cane to produce successful ratoon crops is one of its most valuable characteristics. Under present-day conditions a field cycle of crops, i.e., from one planting to the next successive planting, will seldom include less than the plant crop and four ratoons.

Our first question was, "Under favorable conditions for this cane variety, do the yields of the older ratoons drop off to a point significantly below the yields of the plant crop?" If this question could be answered affirmatively then we should need to give thought to more frequent plowing and planting; if answered negatively, then, unless extra field costs were involved, we might consider an even longer cycle than that now generally adopted.

In order that all sugar yields might be placed on a basis from which fair comparisons could be made, the tons-sugar-per-acre yield (TSA) was divided by the age of the crop (in months) to secure a basic figure of tons-sugar-per-acre-per-month (TSAM).

The field records from 111 fields have quite definitely answered our question—negatively. An inspection of Fig. 1 will clearly show that the TSAM yields from the fourth and fifth ratoons have not been significantly different from those of the plant crops; the crop figures all lie within the range of .448 to .462 tons-sugar-per-acre-per-month, none varying by as much as 2 per cent from the most probable average (.454).

2. Relation Between Sugar Yield and Month of Starting the Crop:

The many disadvantages concerned with starting cane crops too late in the season (after August) or too early (prior to March) have been heretofore accepted as inevitable. Although it is definitely recognized that from an economic agricultural standpoint there is a most opportune time to start cane crops, the physical impossibility of harvesting and milling the annual crop during the short span of best months concerned has forced us to start some crops earlier and some later than is desirable. However, with the acceptance of mechanical harvesting on a 24-hour day schedule, we can foresee a reduction in the overall time needed to take off the cane crop, and providing additional milling facilities are made available, it may no longer be necessary to start many crops in the less favorable, slower growing months.

While it may be true that cane crops started in our mid-season (March-July) will get off to a faster start and close-in before the end of the year, and hence be cheaper to cultivate, is there any relationship between these advantages and the yields of sugar that such crops may produce? The data shown in Fig. 2 would indicate that these advantages are supported by the optimum sugar yields also. Both the best "sugar-per-acre" (TSA) and "sugar-per-acre-per-month" (TSAM) yields from the total of 849 crops studied are found to favor the crops which were started in mid-season; the lower sugar yields are found associated with those crops started before March and after July.

3. Relation Between Sugar Yield and Month of Harvest:

Quite naturally, since a large percentage of our cane is grown from ratoon fields, there is a direct and close relation between the harvesting of one crop and the starting of another. Therefore it would be unfortunate unless the same relationship with sugar yield were found for both the month of harvest and the month of starting. Fig. 3, however, indicates that this similar relationship did exist, and that the best TSA and TSAM yields were obtained from those crops which were harvested in mid-season, with perhaps a suggestion that February was better than July.

4. Relation Between Sugar Yields and the Age of Crop:

Since fewer than 8 per cent of the crops concerned were harvested at less than 18 months of age, the so-called short crop is not included in this study. However, Fig. 4 will show that the sugar-per-acre-per-month value for crops between 19 and 25 months was not consistently different, although the best figure was that found for crops harvested at 24 months. This suggested optimum age for H 109 is also supported by the TSA figures which are found to increase quite regularly with increasing age of crop up to 24 months, and thereafter to drop off.

Conclusions

Unless field costs are concerned with decisions to plow out old ratoons, there is apparently little to be gained by plowing and replanting H 109 unless it is shown that the sugar-per-acre-per-month yields are falling below the normally expected values.

Under the climatic conditions of the Waialua district, optimum sugar yields from H 109 cane should be obtained from 24 months' cropping, and when the fields are started and harvested between the months of February and July.

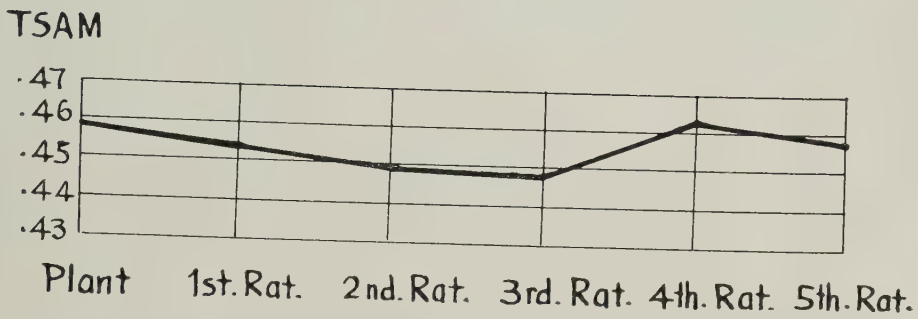

TSAM
·47
·46
·45
·44
·43
Plant
1st. Rat.
2nd. Rat.
3rd. Rat.
4th. Rat.
5th. Rat.

Fig. 1.

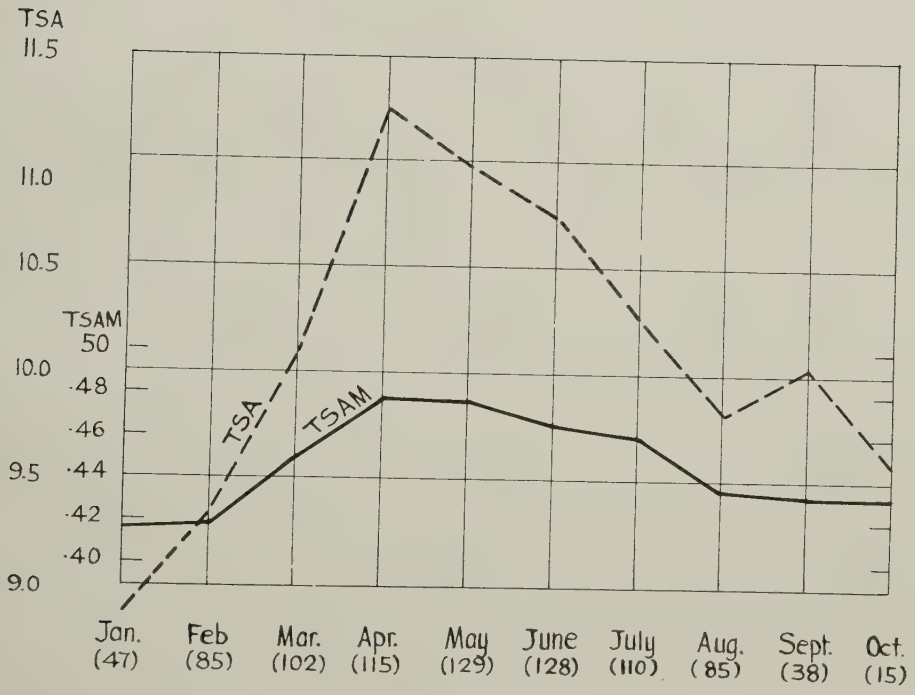
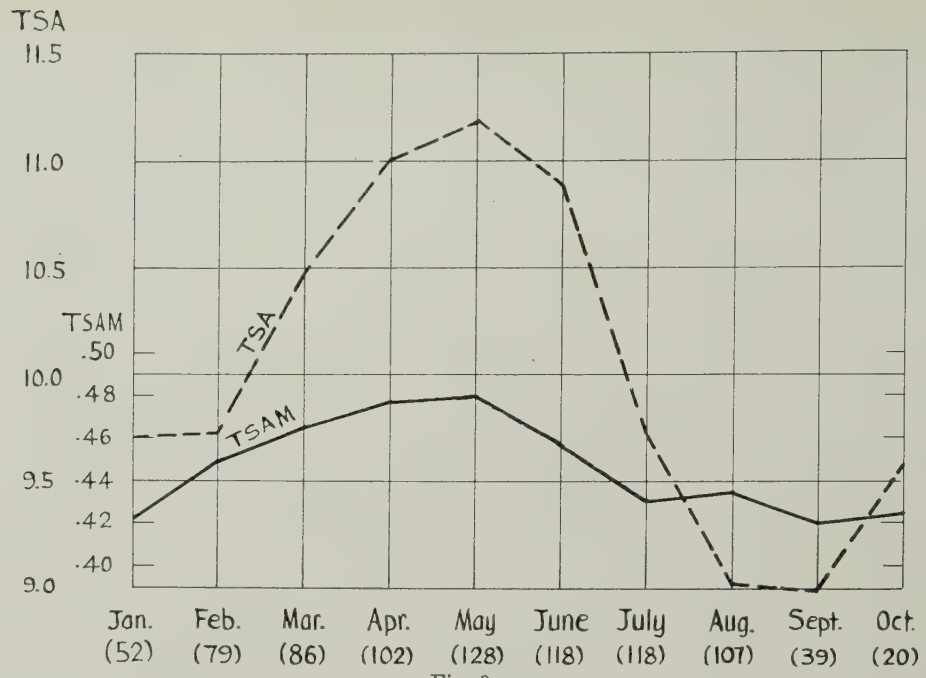

TSA
11.5
11.0
10.5
10.0
9.5
9.0
TSAM
50
·48
·46
·44
·42
·40
TSA
TSAM
Jan. (47)
Feb (85)
Mar. (102)
Apr. (115)
May (129)
June (128)
July (110)
Aug. (85)
Sept. (38)
Oct. (15)

Fig. 2.


TSA
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TSAM
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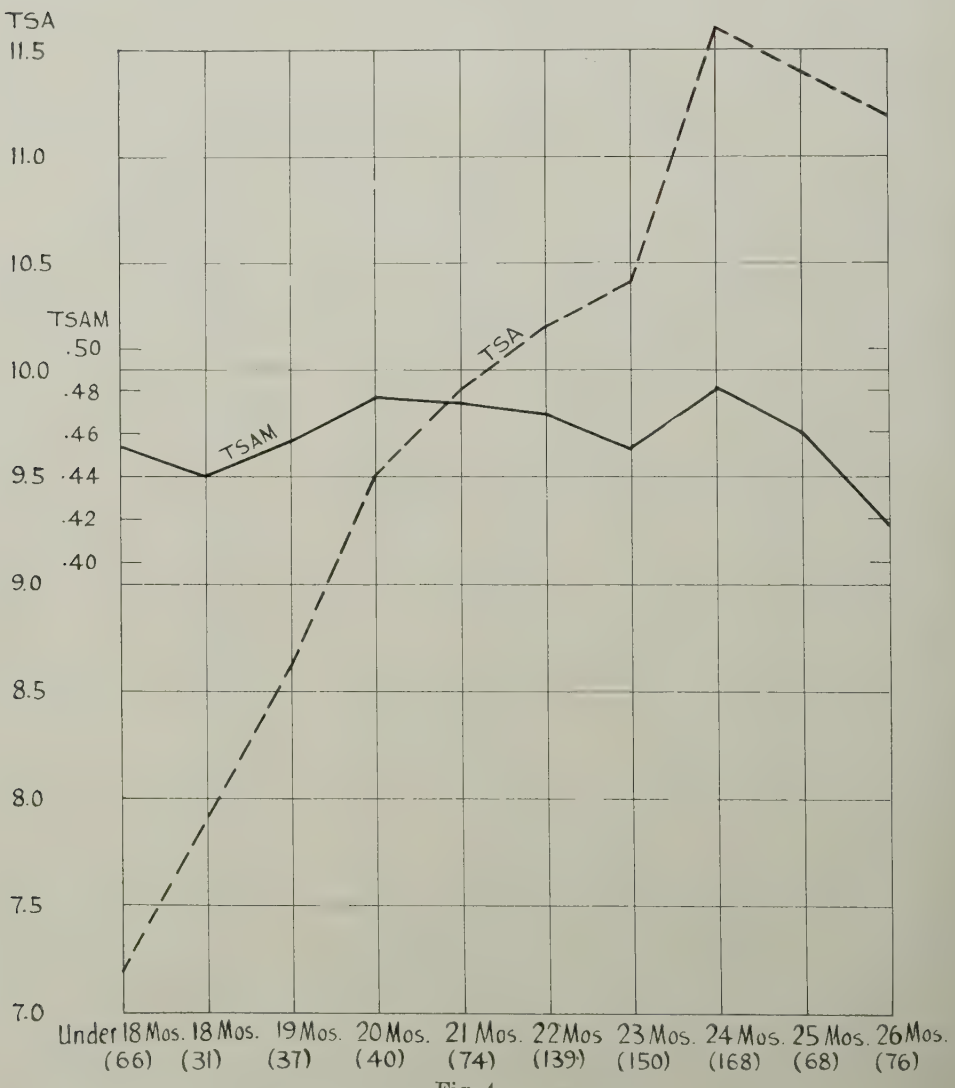
.44
.42
.40
9.0
TSA
TSAM
Jan. (52)
Feb. (79)
Mar. (86)
Apr. (102)
May (128)
June (118)
July (118)
Aug. (107)
Sept. (39)
Oct. (20)

Fig. 3.


TSA
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TSAM
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.48
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.40
9.0
8.5
8.0
7.5
7.0
TSA
TSAM
Under 18 Mos. (66)
18 Mos. (31)
19 Mos. (37)
20 Mos. (40)
21 Mos. (74)
22 Mos (139)
23 Mos. (150)
24 Mos. (168)
25 Mos. (68)
26 Mos. (76)

Fig. 4.

Stem Galls of Sugar Cane Induced With an Insect Extract

By J. P. Martin

The foremost reference on stem galls is by Kamerling (3) who in 1900 described and illustrated such malgrowths on stalks of sugar cane in Java. In 1907 North (10) observed stem galls on Badila cane at Lautoka, Fiji, and later, on Badila and other varieties in Fiji, Queensland, and New South Wales. Lyon (7) stated that stem galls have been known to occur in Hawaii since 1910 and that they were of little importance prior to 1925 when they appeared in epidemic form on a number of the Uba x D 1135 seedlings. Stem galls of sugar cane have been reported in the following countries: Australia, Cuba, Fiji, Hawaii, Java, Louisiana, and Philippines. No serious losses on commercial sugar cane varieties have resulted from this teratological conditon although aggravated cases have developed on certain individual canes in Hawaii, thus making the varieties valueless. These proliferations have been recorded on a large number of varieties in Hawaii which include the majority of the commercial canes; however, on the latter their presence has been of minor importance.

The various types of stem galls appearing in Hawaii have been described and illustrated by Lyon (5, 6, 7) and Martin (8, 9). The first symptom of galls is recognized by the development of watery blisters or slightly raised translucent excrescences on young stalk tissue near the growing point. The galls at this stage of development can be detected only by carefully removing the leaf sheaths from the stalk in the growing-point region. The tissue of stem galls is made up chiefly of embryonic cells which are very irregular in size and shape. The galls soon assume a variety of irregular forms, some of which develop into bud proliferation (Fig. 1) while others develop into large masses of galled tissue (Fig. 2). At times the abnormal growths are confined to the nodal region of the stalk (Fig. 2, lower center) but in most instances the outgrowths or hypertrophies develop on both the nodes and internodes (Figs. 1, 2).

Considerable study by Station Staff members has been devoted to the factor or factors causing stem galls. Plant juices extracted from galls and injected into healthy stalks have yielded negative results. Repeated contact plantings of galled and healthy varieties showed that the healthy plants did not contract the disease. Direct inoculations of diseased tissue into healthy canes failed to produce galls, and isolation studies also failed to associate any organism as being directly responsible for stem galls. Pemberton (11) and Carpenter (2) were of the opinion that the sugar cane stalk mite, *Tarsonemus spinipes,* during its feeding on the stalk, might incite or stimulate certain cells to form stem galls. This particular mite is as a rule present on, and often found close to the growing point of, stalks manifesting galls. A causal relationship between stalk mite infestation and gall formation was indicated by Carpenter (unpublished studies, 1932), who reported that galls on certain cane varieties which always produced galls were prevented by repeated applications of sulphur to the cane tops.

Fig. 1. A, proliferating stem galls on UD 47, many of which have given rise to adventitious buds while some of these have developed into leafy shoots. B, stem galls on UD 47, the majority of which have developed into small shoots. After Lyon (6).

Fig. 2. Stem galls on stalks of UD 1. On the lower portion of the center stalk the galls are confined largely to the nodal tissue. After Lyon (7).

In the Director's Monthly Report of this Station for May 1936, C. E. Pemberton reported the green leafhopper, *Draeculacephala mollipes,* of the family Jassidae, to be somewhat common on sugar cane at Kailua substation. Since other insects belonging to this family, such as *Eutettix tenellus,* the vector of curly top disease of sugar beet, and *Cicadulina mbila,* the vector of streak disease of sugar cane, play an important role in the transmission of virus diseases it was felt that the green leafhopper should be studied in relation to certain cane diseases.

In studies connected with the transmission of chlorotic streak disease of sugar cane, a number of green leafhoppers were collected from diseased POJ 2878 plants and allowed to feed on healthy POJ 2878 plants grown in sand cultures and enclosed in screen cages. No transmission of the disease resulted in these experiments.

On May 20, 1936 the writer collected from 40 to 45 green leafhoppers at Kailua substation and macerated them in a mortar with a pestle in the presence of a small amount of distilled water. The extract was then strained through a thin layer of cotton in order to remove any large particles, and additional distilled water was added to make up a volume of 200 cc. By means of a hypodermic needle each of 4 stalks of H 109 and of POJ 2878, growing in aerated and non-aerated nutrient solutions, was inoculated with the insect extract, both above and below the growing point. Seven weeks later (July 9, 1936), 2 stalks of H 109 and 3 stalks of POJ 2878 manifested definite cases of stem galls on internodes which previously had been inoculated, as shown in Fig. 3. The controls in this test remained healthy.

Fig. 3. The development of stem galls on stalks of H 109 (single stalk on extreme left) and POJ 2878. The stalks were inoculated with an insect extract which was prepared from the green leafhopper, *Draeculacephala mollipes.* Photograph by Twigg-Smith.

In a second experiment, each of 4 stalks of H 109 and of POJ 2878 was inoculated (July 31, 1936) with an insect extract which was prepared as described above. In this test 35 insects were used in the preparation of the extract. At the end of 14 weeks all inoculated stalks were carefully examined and galls were noted on 2 stalks

of H 109 and 3 stalks of POJ 2878, the first evidence of stem galls having been observed at the end of 8 weeks.

In order to confirm the results of the two previous tests a third experiment was installed October 23, 1937. In this test only stalks of the variety POJ 2878 were inoculated with the insect extract prepared from green leafhoppers which again were collected at Kailua substation. Each stalk was inoculated: (a) slightly below the growing point, as near as could be determined, (b) approximately from 10 to 12 inches below the first inoculation, and (c) about 12 inches below the second point of inoculation, the object being to inoculate stalk tissue of different ages. Six weeks after the inoculations were made stem galls were noted on several of the inoculated stalks. On January 19, 1938, when all stalks were critically examined, 9 stalks out of a total of 21 showed definite cases of stem galls, some of which are shown in Figs. 4 and 5. On several of the stalks the galls were found near the growing point only after the leaf sheaths were removed from the stalk. On 3 stalks, long, thin galls were found at the base of the leaf sheath (Fig. 5) but no galls were observed on the leaf blade. Lyon (7) in 1927 reported and illustrated galls on the leaf sheath of the variety UD 47; in this instance the galls had developed under field conditions. It was interesting to note that the apical bud of two of the inoculated stalks had divided into many buds, thus forming bunch top. One of the five control stalks, which were inoculated with distilled water, showed indefinite symptoms of stem galls; on another stalk bunch top was noted while on two other stalks aborted tassels were observed. It is very likely that a number of the inoculated stalks would have produced tassels or aborted tassels since several untreated stalks of a similar age tasseled during November and December, 1937.

While examining the inoculated stalks on which galls had developed it was evident that the outgrowths had developed only when the inoculation was made slightly below the growing point or in stem tissue which was capable of making further growth. Stem galls did not develop on the more mature portions of the cane stalk.

This is apparently the first instance where stem galls have developed on sugar cane stalks following artificial inoculations. It is possible that the green leafhopper, as well as other insects, may carry certain auxins or growth-promoting substances and when such substances are injected into the plant by insects during their feeding, stem galls may develop.

Brown and Gardner (1) reported in 1936 the formation of galls on the red kidney bean which had been decapitated and smeared with an ether extract prepared from sterilized cultures of *Bacterium tumefaciens,* the organism which causes crown gall. They also report gall formation on bean, tobacco, sunflower, and other plants following an application of lanolin mixtures containing indoleacetic and indolepropionic acids to decapitated stems. According to Went and Thimann (12): "The root nodules of leguminous plants are active auxin-forming centers when still growing, and their initiation and growth are almost certainly due to the auxin produced by the invading bacteria. . . . These can therefore be considered as root-galls, arising by pathological swelling of a lateral root initial." LaRue (4) in 1936 showed that leaf outgrowths or intumescences on leaves of *Populus gradidentata* developed when healthy leaves were injected with extracts prepared from gall-bearing leaves;

Fig. 4. Stem galls induced on stalks of POJ 2878. The stalks were inoculated October 23, 1937, near the growing point, with an insect extract prepared from the green leafhopper. Galls were first noted December 2, 1937. Photograph by Twigg-Smith.

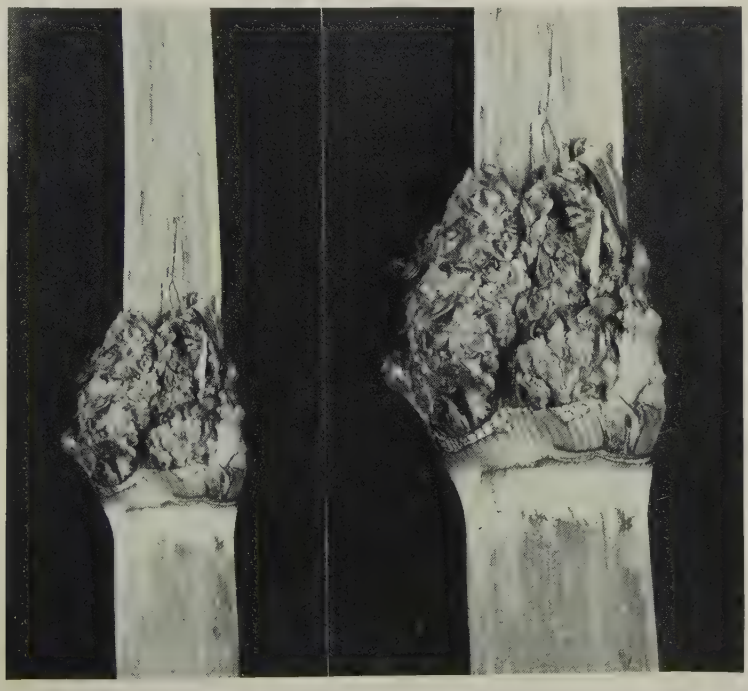

Fig. 5. Stem galls on a stalk of POJ 2878 that developed following artificial inoculation with an insect extract; long, thin galls also developed at the base of the leaf sheath. Photograph by Twigg-Smith.

he also reported the development of intumescences on leaves injected with indoleacetic acid and " . . . assumed that plant hormones are the cause of intumescences on leaves confined in unventilated damp chambers." Went and Thimann (12) state: "Probably many other pathological outgrowths are explicable in terms of auxin —a development which will open important fields in plant pathology." These are only a few of the interesting results being secured with growth-promoting substances and are presented merely to show that galls may be induced on plants when injected with various auxins.

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The Giant African Snail *Achatina fulica* (Fér.) Discovered in Hawaii

By C. E. Pemberton

An omnivorous and highly destructive plant pest entered Hawaii from Japan through the mails in November 1936. Its presence here and the date of arrival have just been determined. It has been identified by Dr. C. Montague Cooke, Jr., Malacologist of the Bernice P. Bishop Museum, as the notorious African snail *Achatina fulica* (Fér.). Considered indigenous to East Africa, this pest has spread eastwards during the past 75 years and caused great destruction to vegetable crops and other plants in Ceylon, India, and Malaya. In recent years it has reached Borneo, Java, and Amoy, China. It is also said to occur not only in East Africa, but also in West and South Africa and the Seychelles (10). It was introduced into Mauritius from East Africa nearly 100 years ago. Although it could be easily conveyed amongst plants transported from one country to another, its spread during historic times seems to have been mostly intentional, both for use as food for ducks, poultry, and humans and possibly for its assumed medicinal value. The circumstances attending the discovery of this pest in Hawaii are as follows:

According to information supplied by L. M. Whitney, Chief Plant Inspector, Territory of Hawaii, a Honolulu resident read in a local newspaper that a Japanese of Makawao, Maui, was raising these snails for food or medicinal purposes. He obtained six living snails from the grower at Makawao and sought information from the Board of Agriculture and Forestry in Honolulu respecting suitable methods for their propagation. This was early in April 1938. The serious nature of the situation was recognized and especially after Dr. Cooke had positively identified the species. The six snails were confiscated and destroyed and Mr. Whitney immediately proceeded to Maui to discover their source. With the assistance of the sheriff and the county attorney of Maui the snail grower was located at Makawao and his establishment inspected. It was found that the snails were being multiplied by the hundreds in covered, wooden boxes, partially filled with moist sand, kept indoors within the grower's house. Lettuce, carrots, and cabbage were being used as food and the snail colony was in a thriving condition. The entire lot was immediately destroyed with boiling water and buried underground. A total of 1,387 snails from two months to one and one-half years of age was counted. The hatchery also contained a large quantity of newly hatched snails and eggs, which were also destroyed. The grower stated that he had already eaten 425 snails. He assured Mr. Whitney that the only snails which had left his hatchery were the six individuals which had been confiscated in Honolulu. Mr. Whitney found no evidence of snails outside the hatchery and it is hoped that none has escaped or been distributed excepting the six that reached Honolulu.

Further investigation by Mr. Whitney revealed that the Makawao resident had imported 12 of these snails through the mails from Japan on November 25, 1936, without informing the Plant Inspectors of the introduction. There was evidently

no conscious evasion of the law intended. Of the 12 imported individuals, 8 arrived alive on the above date and reached Makawao on November 30, 1936.

This mollusc feeds on many kinds of plants, as well as animal and vegetable refuse. Dammerman (4) states that in Java:

> This snail is a serious pest of vegetables and flowering plants; it eats nearly everything in the garden, *Crinum* and other lilies seeming to be preferred for attack, but it is not found on any perennial plant, rice, etc. The snails sometimes occur in such enormous numbers that they are used as poultry-food, especially for ducks, and they were probably originally imported into Singapore for this purpose. They are also eaten by the Malays.

Leefmans (8), in discussing the recent occurrence of the snail in East Java, writes that:

> Damage was only conspicuous on banana leaves, which were rather generally and strongly eaten, which damage looked alarming enough to take measures. Furthermore some damage to orchids and ornamental plants and to the bark of shrubs were observed. Some vegetable gardens were only yet slightly invaded. . . . In the large center at the village Soekaboemi [elevation 2,300 feet] a campaign was organized to have the snails collected by the natives. More than 2 millions were caught, thrown in especially dug small pits, crushed with poles and covered with earth.

This snail has been in Ceylon long enough to have become a pest of real importance. According to Hutson (5) it reached Ceylon about 1900. It had already been recorded in Calcutta since about 1857 and had been introduced there from Mauritius (1) by an enthusiastic malacologist, who used it for purposes of dissection. In describing the damage caused by the snail in Ceylon, Bertrand (2) states that:

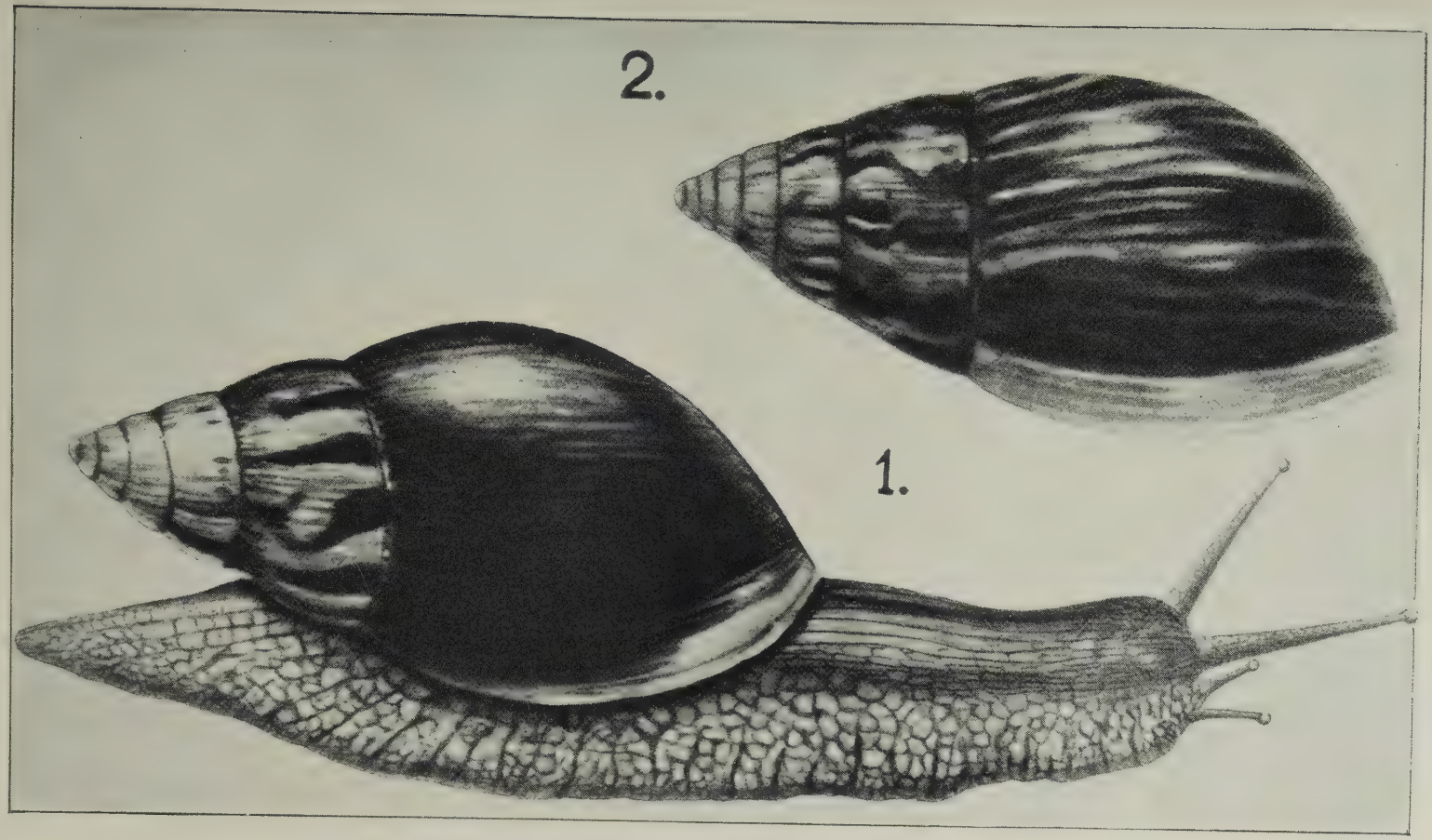
> This pest (*Achatina fulica*), . . . has spread over the whole of the wet zone low-country and is spreading in many Upcountry districts.
>
> It causes immense damage to vegetable and flower gardens and of late years has become a serious menace to certain estate green manures and cover crops. Two years ago this estate [Govina Estate, Horana] was covered with a beautiful carpet of Vigna which has since been almost completely destroyed. During the whole of 1927 all children who came to muster were sent off for an hour or two to collect snails and a total of at least 9,000 working hours was so employed. Towards the end of the year it was realized that the snails had got completely beyond control and the work was stopped.
>
> It was represented to the Agricultural Department that the only effective check which we have against soil erosion in grown Rubber was in danger of extinction and the Department was requested to make enquiries in Madagascar as to what agency there controls the snail. So far the only "control" reported is a big bull-frog which eats them, but the Director of Agriculture is not in favor of such an importation. [Note: The above reference to Madagascar is probably a typographical error. The reference is no doubt to the island of Mauritius.—C. E. P.]

South (10), commenting in 1926 on the presence of the snail in Malaya, states that:

> The exact date when the presence of these snails in Malaya first received attention is uncertain, but the available evidence indicates that they have been present in Kedah and Singapore for about 15 years.

Jarrett (7), in remarking on its status in Singapore says:

> A few notes on the way the creature has spread in Singapore may also be of interest. First taken serious notice of in March, 1922, when it occurred in a small area in the heart of the island, it rapidly spread. In 1928, the writer passed through Singapore while going on leave, and learned that the snail had become a thorough pest in gardens all over the island. One house in the Tanglin residential district was visited, and there the molluscs were shaken out of a hedge like ripe apples off a tree!
>
> Latest information [1932] from Malaya is that the snails are now found in increasing numbers everywhere, and even wander over the golf courses, where the chagrin of a player whose ball is stopped by a giant mollusc in the grass may be imagined.



Giant African Snail *Achatina fulica* (Fér.). Natural size.

1. The crawling snail with its shell. 2. The shell showing variations in color pattern.

(From Leefmans and Van der Vecht, Landbouwkundig Tijds chrift Voor Nederlandsch-Indie, Vol. 8, page 670, 1932-33.)

The snail is a comparatively recent arrival in Borneo. Referring to its history there Jarrett (6) states:

Introduced there from Singapore, apparently as feed for poultry carried across as live stock, in 1928, the snail was identified at Kuching the following year, and by 1930 was already a pest. This year, serious efforts have been made to keep its numbers down, and a small reward was offered to the natives for its destruction. Between October 1 and October 15, 1931, approximately half a million snails and twenty million eggs were destroyed! The increase of the mollusc in only three years seems almost phenomenal, and serves as a warning to us in China. The reference to eggs in October seems to establish, what was long suspected, that in the equatorial region, where there are no marked seasons, these snails probably lay as soon as mature, possibly throughout the year.

South (10) has given a good description of the life history and development of the snail. He says:

Achatina fulica has a shell which in average local specimens [Singapore] is between 4 and 5 inches long, though occasionally examples may be found as much as 6½ inches long. The greatest width is between 1½ and 2 inches.

The snails probably take two years to attain their full size, but are capable of laying eggs at the end of the first year when half grown. So far as is known at present, the eggs are laid only once a year. . . . In Ceylon and India the half grown snail lays about 100 eggs in a pocket and the full grown snail from 200 to 300. Each individual is bi-sexual, as is usual in the snail family, but pairing may be necessary to produce fertile eggs.

The eggs are about the size of a large pea. They are round and yellow, with a hard shell like that of a bird's egg. Batches of eggs are laid in shallow pockets just below the surface of loose soil in sheltered places. Thus they can be found in soil at the foot of trees, under hedges, below rank vegetation, under large stones, broken bricks and crockery or old ironware, or in heaps of vegetable refuse or manure.

Hutson (5) states that under favorable conditions eggs may hatch within two or three weeks after being deposited. The young snails are about the same size as the eggs and emerge with their own body shells fully formed. They feed voraciously at an early age and are quite inconspicuous for the first month at least. The Giant Snails feed mostly at night and in the early morning. During the heat of the day they rest, usually in sheltered places, as for example under hedges, under thick vegetation, under trees and in rubbish heaps. Where they are numerous, they are also to be found resting on the trunks of trees, the stems and branches of hedge plants, the sides of drains, or the walls of houses.

Hutson (5) further says:

These snails are active only during wet weather and retire during dry spells to sheltered places, closing up the mouth of their shells by means of a parchment-like cover, the hibernaculum, which they secrete as required.

During the wet weather the snails do most of their feeding at night, especially in the younger stages, and many of them retire in the early mornings to selected retreats, coming out again at night. When very numerous a large number do remain above ground all day in a quiescent state, clustering thickly on trees, hedges, fence-posts and buildings, and advantage can be taken on this habit to treat with copper sulphate the places where they congregate, or simply to collect and destroy them.

Jarrett (6), in discussing the outcome should the snail be introduced into Hong Kong, China from Amoy, where it has been found, says:

It need hardly be mentioned in conclusion that this snail is a very destructive visitor to gardens or vegetable plots, as its tastes are omnivorous. Lily plants, all succulent herbs, cabbages and lettuces, and anything that is not too hard or distasteful, will be devoured. A few specimens of this mollusc in a Peak kitchen garden patch would probably, in a single night, consume the product of the whole season's devoted toil.

Artificial control of this pest has been attempted with some measure of success over small areas in several countries. Hutson (5), Jarrett (6), South (10), Corbett (3) and others have discussed the use of copper sulphate ($CuSO_4$) solutions as a poison. Hutson says:

> A 4 per cent. solution (2 lb $CuSO_4$ dissolved in about 5 gallons of water) will kill all snails if these are immersed in it for about 5 minutes.

He states further that when used out-of-doors copper sulphate in crystal form is effective when placing:

> . . . a small piece of copper sulphate near each young plant. The snails on coming to feed on the plants tend to crawl around them first and come into contact with the copper sulphate crystal sticking out of the ground. These crystals last indefinitely.
>
> Any fine powder or dust, such as sifted wood ashes, sawdust, or coconut husk dust, can be steeped in the 10 per cent. solution of copper sulphate for several hours, and then used as a barrier for vegetable beds, plants, or trees, either in shallow ditches, or sprinkled over a wall of stones.

Hutson found rope, so treated, also an effective barrier for individual plants or flower beds of small size.

One important natural enemy of the snail has been found in India. This is a large glow-worm *Lamprophorus tenebrosus* Wlk. The larva feeds specifically on snails and preys extensively on the Giant Snail and is otherwise harmless both as a larva and adult. Paiva (9) has given an excellent account of its interesting habits.

Corbett (3) refers to inquiries made respecting natural enemies of the snail in East Africa, where it is considered native and states that none has been discovered; but that the snail is not regarded as a pest in that region. He mentions the possibility of dry climate being responsible for its comparative rarity and also suggests the probable effect of predatory birds and snakes. Reference has already been made to the reported usefulness of the "Bull-frog" of Madagascar which feeds on the snail. (Note: This is, as stated before, probably a mistaken locality and Mauritius is meant and the "Bull-frog" is probably a large toad common in Mauritius.—C. E. P.) Ducks and poultry have also been mentioned as feeding on this snail. Hutson (5) says:

> Recent information from a correspondent indicates that wild pigs devour snails in the jungle, while recent letters in the daily press state that the "Jungle Crow" or "Etikukula" (*Centropus chlororhynchus*) is very fond of the snails in some localities.

Hutson mentions also that no internal parasites are as yet known to attack the snail. It is probable that *Bufo marinus* would feed on the young snails, should the pest ever become established in regions where the toad occurs.

We find no records of this snail feeding upon sugar cane or pineapples. In India definite observations have established the belief that the snail will not feed on growing rice. In view of this it can hardly be expected to attack sugar cane.

The accompanying excellent illustration, taken from Leefmans and Van der Vecht, Landbouwkundig Tijdschrift Voor Nederlandsch-Indie, Vol. 8, page 670, 1932-33, shows in perfect detail the appearance of the snail and the shell which it occupies, in natural size.

Note: Since the above was written six more lots of this snail have been discovered in Honolulu, totaling nearly 800 snails and many eggs. These are reported by the growers to be the progeny of two snails brought into Honolulu alive by a woman returning from a visit to Formosa in 1936. They were carried in a suitcase

and not detected by inspectors, nor were they declared. Another lot was also discovered on Maui recently. These belonged to a resident in a pineapple plantation camp. All of these new lots of snails have been destroyed.

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Defining Colloidal Solutions*

By Hugo P. Kortschak

Before one tries to talk about anything, one should know what one is talking about. However, in trying to define the term "colloidal solution" one immediately runs into difficulties and contradictions. The most usual definition depends on the order of magnitude of the size of the particles dealt with. When the cross section of at least one of the dimensions of the particles lies between 10^{-7} and 10^{-5} cm., you have a colloidal dispersion.

Now, that would be a very nice definition, except for several objections. One is, of course, that there is no sudden change in properties as these limits of size are reached. There is no great difference between such particles and those which are just outside these boundaries. Also, there are many substances which, especially when the diameter is near the upper limit, can hardly be considered colloidal at all.

Another definition would say that colloids will pass through filter paper, but not through semi-permeable membranes. That would leave the decision up to the fineness of the filter paper and the kind of membrane. In fact, all measurements which require that a substance pass through any sort of filter are very difficult to evaluate. Just to illustrate: a suspension of gold which will be held back by a filter paper will pass through it easily when a small amount of gum is added, which increases the size of the particles. We usually think of a filter as a kind of sieve, but this is true only for very coarse material. As the material is more finely subdivided, absorption plays a very great role, as do electrical effects.

A definition which would narrow the field far more than is commonly accepted depends on the settling or not settling of the material. This would, in fact, eliminate almost all of the simple cases where complications such as hydration are lacking. Certainly there would seem to be a fundamental difference between, for instance, a suspension of chalk in water which will settle in a few hours, leaving a clear liquid above, and a solution of dye which may be kept for years with no evidence of sedimentation. The former type is often called a suspension; the latter, a truly colloidal solution. What, however, is sedimentation? It does not mean, as is so often assumed, that all the disperse matter separates from the medium. On the contrary, an equilibrium distribution is reached, which may be calculated from the barometric formula, in the same way that the barometric pressure for various heights above the earth's surface is calculated. If you have a pile of rocks under water, you can calculate how many will be floating ten feet above the bottom. Unfortunately, no one has ever made a large enough pile of rocks, or watched it long enough, to verify the prediction experimentally. Perrin, with particles of gamboge 3.7×10^{-3} cm. in radius, verified the value of N, the gas constant, by showing that the concentration decreased 50 per cent in the height of one-tenth of a millimeter, which compares with 5,000

*Presented at a meeting of the Hawaiian Section of the American Chemical Society, March 24, 1938.

meters for a 50 per cent decrease in the pressure of the atmosphere. With the naked eye, one would think Perrin's suspension had settled completely.

On the other hand, we have colloidal solutions which do not appear to settle at all. This led to the belief that the barometric formula failed for such dispersions. However, Svedberg pointed out the simple fact that even the slightest non-uniformity in temperature, caused, for instance, by somewhat one-sided illumination, would set up convection currents strong enough to mask the settling. In recent years, with the development of the ultra-centrifuge, it has been shown that even such a very stable solution as one of sodium chloride settles out exactly as the formula requires for particles of the size and density involved. So this definition—that colloids do not settle—must be abandoned because we are unable to find anything which conforms to the definition.

The truth of the matter is that we have tried, as usual, to force nature into a straitjacket of our own contriving and find it impossible. We are left to the conclusion that no exact definition is possible. We have a general idea as to what we mean, and in every particular case we must make an appropriate definition for ourselves. How important this can be is shown in the sugar industry. In many investigations sucrose solution is considered to be colloidal, but when a sugar boiler wants less colloids in the syrup he certainly does not include sucrose under that heading.

We probably get a better idea of what colloids are when we consider the various forces which may be active in holding the particles in solution.

The simplest case is where the substance is inert and the only effective force is the friction against the medium. Even here we can only predict the behavior of the suspension when the particles are spherical and when the radius, densities and the viscosity of the medium are known. For such a case, Stokes' law for the velocity of falling particles, with the barometric formula, will give us a fairly exact picture of what will happen when such a suspension is allowed to stand. I repeat, that is the simplest case. We can make suspensions of this kind but would be hard put to find a single example in nature, especially among the biological colloids, which are the most interesting and important.

As soon as the particles reach a size of less than 10^{-4} cm., the effect of the Brownian movement becomes noticeable. Some of you may have read about colloid chemistry and become confused by what are called "critical radii," which make it appear to the unwary that the Brownian movement can prevent settling. This is not the case. In our simplest kind of suspension we can calculate the *average* displacement, parallel to any given axis, which will be caused by the Brownian movement for any specified length of time. When this distance is greater than the fall of the particles during this time, the effects of sedimentation will be masked. However, as the Brownian movement is completely random (being caused primarily or secondarily by the kinetic motion of the molecules of the medium) this average displacement must approach zero as the length of time is increased. Thus, the average settling velocity will not be affected at all.

What *will* be affected is the equilibrium which is reached, for without the Brownian movement there would be none. The Brownian movement is evidence of the fact that the particles have kinetic energy. In the usual barometric formula we find a temperature term, but temperature is only a measure of kinetic energy. Thus,

the greater the Brownian movement, the less the particles will have settled at equilibrium.

Up to now I have been discussing the colloids as if the colloidal particles had no effect on each other, were indeed, like the classical atom, perfectly elastic spheres. The forces of attraction and repulsion are very important. When the forces of attraction become effective, the particles become attached to each other, on contact, forming larger and larger aggregates which settle out rapidly. This is called coagulation. A preponderance of repulsive forces obviously prevents this taking place.

Picture to yourself a pile of coil springs, one on top of the other. If the springs are strong and the pile not too high, it will seem as if even the bottom spring is not compressed at all. As we build the pile higher though, the springs at the bottom will become more and more compressed. Thus, in a colloidal solution, when the repulsive forces are strong, it may appear that sedimentation has been completely negatived. This is only due to the grossness of our observations, however. A concentration gradient is always present and can be clearly shown by substituting the force of the ultra-centrifuge for gravity, or by using sufficiently high vertical tubes.

In most cases these repulsive forces are of an electrical nature. They may be produced by several effects. When the colloidal material has the nature of an acid, base or salt, true ionization takes place. The soaps are a good example. Let us examine the more common case—that of an acidic substance. When the hydrogen-ion concentration of the solution is small, the substance will be largely dissociated into hydrogen ions and a colloidal, negatively charged residue. These negative particles repel each other and cannot coalesce. If the hydrogen-ion concentration is increased, the ionization is repressed to an extent dependent on the dissociation constant of the acid. There will be more neutral particles present and when these collide, their cohesive attraction may hold them together. Thus, as the pH of the solution becomes lower, the velocity of coagulation becomes greatly increased. The case of a basic colloid or a salt, which hydrolyzes, is of course similar.

An important fact to keep in mind is that in such a case, where true electrolytic dissociation is the cause of the electric change, there is no definite hydrogen-ion concentration at which coagulation takes place, for there are always some undissociated molecules (or neutral aggregates of molecules) present. Thus there is always a finite velocity of coagulation.

Another source of electric charges may be absorption. If a dilute solution of potassium iodide is treated with dilute silver nitrate, the sol is not stable if exactly equivalent amounts are used. If there is a small excess of silver nitrate, the sol is stable and positive; if there is a small excess of potassium iodide, the sol is stable and negative. This is interpreted to mean that in the presence of silver nitrate, the silver ions are absorbed by the silver iodide particles while the nitrate ions are not, thus resulting in a positively charged sol. In the presence of potassium iodide the reverse is true; iodide ions are absorbed, potassium ions are not, resulting in a negative sol. Suppose we have a stable sol of this kind and add any substance which dissociates electrolytically. The resulting ions will be absorbed in differing degrees by the sol. If the sol is positive and the added positive ions are more strongly absorbed than the added negative ions, nothing will happen; the sol is even more stable than before. However, if the added negative ion is preferentially absorbed,

it will tend to neutralize the charge on the particles. As more and more of the salt is added, a point is reached at which the absorbed negative ions have completely neutralized the positive charge on the colloid. The protective electric charge being thus removed, coagulation can take place. Actually, of course, exact neutrality is not necessary. There is a finite cohesive force between the particles and all that is required for coagulation is that the repulsive force be smaller than this. Thus there is a narrow zone of small charges, corresponding to a concentration range of the added electrolyte, in which coagulation takes place. For, suppose we add more of the salt than is required to neutralize the positive charge on the sol. If it is added rapidly enough, enough negative ions will be absorbed to give the sol a negative charge before it has had time to coagulate. This is called "reversal of charge." The addition of electrolytes may also cause coagulation if an insoluble or non-dissociated compound is formed with the absorbed ion.

A source of electric charges which is most common in aerosols, that is smokes or fogs, is ordinary static electricity, caused by friction. Such charges may reach a very high potential; dust explosions and lightning may be caused in this way.

One very important factor which keeps colloids in solution is hydration. Whether colloidal particles carry a water (or other solvent) sheath is largely dependent on the chemical nature of the substance of which they are composed. So-called hydrophobic sols, suspensoids, such as those of metals, carry little or no absorbed water; while hydrophilic colloids, or emulsoids, appear to be associated with large hydration. Such a water layer around the colloid particles keeps them from approaching each other and thus prevents the formation of larger aggregates. Any change which will remove this water layer will cause flocculation.

As to the amount of water which is bound in this way, opinions differ. From Einstein's viscosity equation, the volume of the hydrated particles may be calculated. The ratio of this volume to that of the unhydrated particles ranges from 0.9 for egg albumin, and 1.6 for sucrose, to 220 for agar in water, 300-500 for rubber in benzene and 200-900 for polyvinyl acetate in benzene. And now, please forget these figures. They are probably worth exceedingly little. For the factor of 2.5 which goes into the Einstein equation is true only for spheres. It is probably many times 2.5 for long, rod-shaped particles. Since the factor for non-spherical forms has not been worked out, and particle-shape cannot be determined with any accuracy anyway, there is at present no possibility of quantitative evaluation of such measurements. Other measurements of hydration are no better, and the various methods do not give concordant results.

It is difficult to know how the water of hydration is situated with respect to the rest of the colloid particle. In some cases, no doubt, it actually assumes the form of a nearly spherical shell. In others, it is thought that the particle itself is porous and the water fills the pores as it would a sponge.

Hydration is not, of course, limited to matter in a colloidal form. Most ions are assumed to be hydrated. The so-called hydrogen ion, for instance, being probably a monohydrate, H_3O^+, to a great extent, with unhydrated ions present only in a very small concentration in any aqueous solution. So we have here another link between colloids and true solutions.

All the properties that have been mentioned in this discussion are in one way or another connected with the surface of the particles. The fact that sedimentation takes place, instead of a practically instantaneous falling of the particles, is due to friction; Brownian movement is evident only when the moving surface is large enough to be apparent to us; absorption and, in many cases though not always, hydration are determined by properties of the surface. These properties are most evident when particles are so small that the surface area is relatively large, but when they are large enough so that it is possible to conceive the surface as being relatively homogeneous.

Thus colloid chemistry is the study of systems where the reactions of surfaces are important, and it is also known by the perhaps better name of surface chemistry.

The Introduction Into Hawaii From Mexico of Insect Parasites to Control Armyworms (1923-1924)

By Herbert T. Osborn*

At the request of D. T. Fullaway, Territorial Entomologist, the writer was granted leave of absence from the Hawaiian Sugar Planters' Experiment Station in August 1921, and commissioned by the Territorial Board of Agriculture and Forestry to conduct entomological investigations in the southwestern part of United States and in Mexico. First consideration was to be given to insects which might be of benefit in the hornfly problem, and attention was to be given to mealybug enemies and armyworm enemies as opportunities presented.

In the spring of 1923 the search for armyworm parasites in Mexico was taken up more definitely by an arrangement supported by both the Hawaiian Territorial Board of Agriculture and the Experiment Station of the Hawaiian Sugar Planters' Association. Fred Muir and O. H. Swezey advised me particularly to endeavor to obtain the *Euplectrus* and *Apanteles* which Albert Koebele had sent from the State of Morelos in Mexico in 1902 and which had failed to become established. It was also desired to secure colonies of *Calosoma* beetles which had been sent by Mr. Koebele at various times but failed to become established. Some search had been made in the vicinity of Cuernavaca and Cuautla, Morelos, and in Atencingo and Rabosa in the State of Puebla in the fall of 1922, and in the early spring of 1923; however, the desired insects were not encountered and the conditions for collecting were quite undesirable. Early in March 1923, the fall armyworm (*Laphygma frugiperda*) was injuriously abundant on corn about Cordoba, Vera Cruz, and occasionally appeared in young cane (damage by *Laphygma frugiperda* was frequently noted in widely separated sections of Mexico), but it was considered more desirable to work in infestations of *Cirphis* if such could be found.

After a short stay at Cordoba return was made early in March to the Hacienda El Potrero, Vera Cruz, where work proceeded on armyworms and continued for several months. The Hacienda El Potrero is an American-owned sugar plantation of some 15,000 acres largely planted to sugar cane, but with extensive pasture and woodland. Through the courtesy of A. H. McLane, the general manager, I was privileged to live at the plantation central. This proved to be an ideal arrangement for the projects in which I was then engaged. I had been told that occasional outbreaks of caterpillars occurred in cane in that vicinity, and in my previous visits I had occasionally noticed some slight evidence of armyworm attack.

In searching over the plantation it was found that small infestations occurred, although seldom more than a few acres in extent, and that there was a very scattered occurrence of the caterpillars in wider areas. The species present were of the genus *Cirphis* and most of the individuals which I reared were *Cirphis latiuscula*. The

* Associate in Plant Pathology, The Rockefeller Institute for Medical Research, Department of Animal and Plant Pathology, Princeton, N. J.

caterpillars of this species hide away in the daytime and can be found by stripping down the cane leaves. Usually they were in well-grown cane, and could be located by their characteristic feeding effects on the cane leaves.

Discovery of *Euplectrus platyhypenae* and Its Introduction Into Hawaii

Almost at once it was evident that the two parasites *Apanteles* and *Euplectrus* were present. The *Euplectrus* being external in its feeding habits was more readily detected and collected for shipment and, in those early infestations, it appeared to be the more effective, breeding up quickly on the small caterpillars and suppressing the incipient outbreaks, at least temporarily, so completely that it interfered with the collecting of other species of parasites.

The method of attack and development of *Euplectrus* on the armyworms also made it particularly easy to ship them after collection, and it was thought best to make trial shipments at once without waiting to study the life cycle, although it was evident that this would be completed very quickly. The parasite eggs were laid in clusters on the body of the armyworm, externally, and the larvae, when hatched several days later, also fed in clusters on the outside of the body. From 20 to 40 or more parasites would develop on one host. The larvae develop to their full size in a very few days, and when full-grown migrate to the underside of the dead caterpillar body and spin a threadlike mass which fastens the body of the caterpillar to a cane leaf or other object, the parasites pupating within this matrix.

Shipments were made of all stages of the parasite from egg to pupa, but it was later found that because of the short life cycle, only those sent in the earlier stages had a chance of arriving in Honolulu alive. With the very best connections it took at least three weeks from the time of collection in the field at El Potrero to the arrival of the shipment in Honolulu. Material for the first shipment was collected near El Potrero from March 13 to 16, and, as it happened, the best recovery of *Euplectrus* in Honolulu was secured from this shipment. Mr. Swezey who handled the shipment on arrival in Honolulu secured 454 living adults of *Euplectrus platyhypenae* Howard from the lot.*

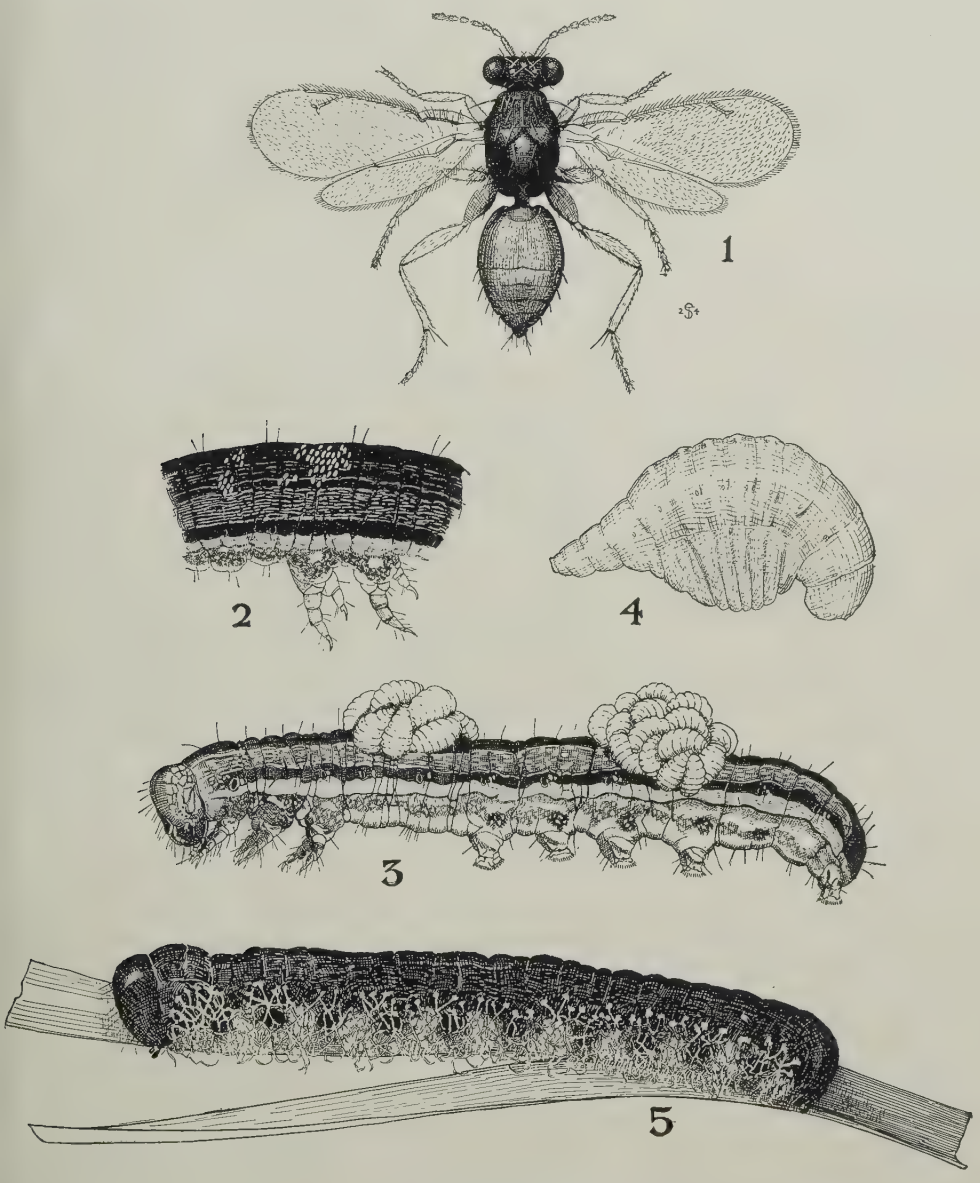
Several additional shipments of *Euplectrus* were made in the succeeding weeks although the infestations of *Cirphis* were being held to insignificant numbers. No attempt was made to breed parasite material for shipping, the parasitized caterpillars used being those collected from the field. Any caterpillars found not attacked by *Euplectrus* were held in the hope of rearing out other species of parasites.

In May, small caterpillars of the commonest armyworm began reappearing on young ratoon cane, and plans were made for shipping some of these on the chance of catching the internal parasites (*Apanteles* and others) before the hyperparasites got them.

Soon after this a letter was received from Mr. Fullaway telling of *Euplectrus* being reared in Honolulu at both the Board of Agriculture and at the Experiment Station, H.S.P.A. On learning this, shipments of *Euplectrus* were discontinued and attention was turned to other species of armyworm parasites. (Within a year

* The details of this shipment are given by Mr. Swezey in The Hawaiian Planters' Record, 28: 318-320, 1924.

45,000 of the parasites were reared and distributed to all the sugar plantations and other places where it was learned that armyworms were present. It was found to have become established late in 1924 on the island of Hawaii and later on the other Islands.)



Euplectrus Platyhypenae

A Mexican armyworm parasite which has been introduced and widely distributed in an effort to control armyworms.

1. Adult female, x 15.
2. Part of an armyworm showing clusters of white eggs, x 4.
3. Armyworm with two clusters of full grown parasite larvae, x 3.
4. Full grown parasite larva, highly enlarged.
5. Dead armyworm fastened to leaf by the cocoons of the parasites, x 3.

Apanteles militaris (Walsh)

Considering that some of the other parasites might prove just as valuable in Hawaii as the *Euplectrus,* I had hopes of securing some of them before leaving El Potrero or perhaps find them also at Puebla. It is hard to value the different parasites where the issue is confused by the presence of hyperparasites and other factors. Once a small lot of pupae of *Euplectrus* brought in from the field and retained in the laboratory yielded mostly hyperparasites.

Another parasite very common in the spring of 1923 at El Potrero, Vera Cruz, in the incipient infestations of *Cirphis latiuscula* was a species of *Apanteles.* The white cottony masses of cocoons on the dead caterpillars made by this parasite were very conspicuous in the cane fields, but the earlier larval stages were not so easy to find since larvae feed and develop internally in the caterpillars. For this reason it was more difficult to collect this parasite in stages early enough for shipping to Hawaii. After the cocoon stage was reached it was too late to ship without emergence of the adults before arrival. Caterpillars shipped from infested lots either failed to contain parasites, or if they did, the parasites emerged and died enroute. Also in the vicinity of El Potrero the cocoons collected in the field were found to yield a very high percentage of hyperparasites.

In December 1923, while on the west coast of Mexico at Los Mochis, Sinaloa, several thousand cocoons of an *Apanteles* were secured and sent to Hawaii. At this season it was much cooler and I was also shipping much more direct, so that a very considerable number of the *Apanteles* emerged in Honolulu and were liberated in the fields. Attempts were made to breed this particular parasite continuously at Los Mochis, but no definite results were obtained. This *Apanteles* was identified as *Apanteles militaris* (Walsh). It failed to become established in Hawaii. It is possible that this species is more specialized in its host relationship than is *Euplectrus.*

Small Tachinid

At El Potrero, Vera Cruz, in July and August 1923, after the rainy season was well advanced, an outbreak of armyworms of greater intensity developed over an area of several hundred acres, and it appeared for a while as if it would become even more widespread. As the generation of caterpillars reached maturity, however, they suddenly became so heavily parasitized by a small tachinid fly that very few reached the adult stage. I had previously reared out a few of this tachinid, which is distinguished by the fact that it completes its development in the larval stages of the *Cirphis.* It also differs from some of the other tachinids in Mexico in that several may develop in a single host. Occasionally up to five or six may be obtained, although many caterpillars have only one, and the average probably not over three or four.

From the rapidity with which it overtook a threatened outbreak of the *Cirphis* it seemed to me as possibly the most promising of the parasites observed on the armyworm in Mexico. Large numbers of the tachinid puparia were collected and two shipments made to Honolulu, but because of the extremely short life cycle all of the flies emerged before arriving in Honolulu and were dead when the consignments

were received. No identification was obtained for this tachinid. [With air service it should be possible at some time to introduce this tachinid into Hawaii successfully.—O. H. S.]

A Large Tachinid, *Archytas cirphis* Curran

At El Potrero, Vera Cruz, in the spring of 1923, and in fact wherever I collected armyworms in Mexico, tachinids would be found to be present. One type was very large, developing in the armyworm caterpillars but usually pupating in the chrysalis of the armyworm. Several consignments containing this type of tachinid were made from Vera Cruz but the caterpillars were so scarce at the time the collecting was done that only a few were sent. Quite a few of the flies issued in Honolulu, however, and an attempt was made to rear them in a cage, which resulted in failure.

Archytas cirphis

In December 1923, while at Los Mochis on the west coast of Mexico, I collected a few of what I took to be this same species and sent a few puparia to Honolulu in January 1924. They arrived in good condition and a few flies issued and were released directly into the field where armyworms were present. Despite the very small number released—nine—the fly became established in about one year's time and eventually spread to all of the Hawaiian Islands.*

* The release, recovery, distribution, etc., in Hawaii, and an account of the larviposition habit of this fly are given by Mr. Swezey in Proceedings of the Hawaiian Entomological Society, 6: 499-503, 1927. Its description by Curran is on page 497 of the same publication.

Results From the Introduction of Parasites of the Armyworms

It is much more difficult to make a definite statement as to the results of the introduction of the two parasites—*Euplectrus platyhypenae* and *Archytas cirphis*—into Hawaii than it was in the case of the introduction of *Pseudaphycus utilis,* the parasite which has given 100 per cent control of the avocado mealybug. There have always been wide fluctuations in the abundance of armyworms in Hawaii. Also, two species of very efficient parasites on armyworms, *Hyposoter exiguae* (Viereck) and *Telenomus nawai* Ashmead, have appeared naturally in the islands within recent years. It will perhaps be several years before it is safe to consider that a balance has been established and, in case it develops that the armyworms are not completely controlled, it may be considered advisable to make additional introductions. A great many parasites quite likely as effective as those already introduced are known to occur in various localities and no doubt many more could be found if intensively searched for in different localities. One shipment of about 150 beetles of *Calosoma semilaeve* Le Conte was made from Cuernavaca in 1923. They arrived in good condition and attempts were made to rear them but apparently they did not become established, nor have efforts to establish carabid beetles from California been successful.

R. A. Vickery made a study of *Cirphis latiuscula* in the gulf coast region of Texas (*Journal of Agricultural Research,* 32: 1099-1119, 1926). *Apanteles militaris* is considered by him as the important parasite in Texas, and *Euplectrus platyhypenae* is recorded as reared from a small percentage of caterpillars. Obviously, it would have been easier to collect and ship parasites from Texas than from Mexico. At the time I took up that work, however, I was already working on other projects in Mexico. As it has turned out, while I might have collected the *Euplectrus* in Texas, the tachinid *Archytas cirphis* is not listed from Texas by Vickery, nor does the smaller tachinid which I found in Vera Cruz appear to be in the Texas list.

Introduction Into the Hawaiian Islands of Mexican Enemies of the Avocado Mealybug

By Herbert T. Osborn*

While on entomological investigations in Mexico for the Board of Agriculture and Forestry of Hawaii, the writer was instructed among other things to give attention to the study of enemies of mealybugs, particularly for the avocado mealybug, *Pseudococcus nipae* (Maskell), and the pineapple mealybug, *Pseudococcus brevipes* (Cockerell).

The avocado mealybug had been a serious pest on avocado, fig, guava, mulberry, some of the palms, and other trees and shrubs in Hawaii for a considerable time. Albert Koebele had made several introductions of enemies for this mealybug but none had proved efficient.

Although some search was made while I was on the west coast of Mexico in the States of Sonora, Sinaloa, and Nayarit in the fall and winter months of 1921, it was not until the spring of 1922 that, at D. T. Fullaway's suggestion, I transferred to the east coast of Mexico and began work more particularly on the mealybugs. Arriving in Vera Cruz early in March, a short time was spent in locating a favorable region in which to work on *Pseudococcus nipae*. Under the conditions existing at the time it seemed that Orizaba was a more favorable locality to work in than Jalapa, where Silvestri had reported the efficient ladybeetle *Hyperaspis silvestrii* Weise to be present. (This was shortly after the Revolution of 1920 and railroad service in many sections of Mexico was uncertain. Service was maintained through Orizaba to Mexico City and from Mexico City to El Paso, however, with only occasional interruptions.)

As a locality for the collection of enemies of *Pseudococcus nipae,* Orizaba subsequently proved to be exceptionally satisfactory. Located on the main line of the Mexican railroad between the port of Vera Cruz and Mexico City, it is about 70 miles from the Gulf of Mexico, and at an altitude of about 4000 feet. Being on the east slope of the mountains that rise to 18,000 feet, it is subject to a heavy rainfall that extends through a much greater part of the year than in many sections of Mexico. Avocados were very abundant in that locality, nearly all of the gardens in the city and surrounding country having some trees, and in many instances they were growing almost semi-wild in clearings on the mountains and along the trails. Guavas were also abundant both in gardens and growing wild along the railroad tracks and in wastelands, so that to one living in the city of Orizaba, there would be easily accessible an abundance of host plants available for the mealybugs.

Preliminary observations were made in several nearby localities. On March 15, at El Potrero, about 25 miles from Orizaba, and at an elevation of only 2000 feet, *Pseudococcus nipae* was noticed on avocados but the infestation was very slight. A few *Hyperaspis* were secured from this infestation, however. At this time the

* Associate in Plant Pathology, The Rockefeller Institute for Medical Research, Department of Animal and Plant Pathology, Princeton, N. J.

mealybug infestation seemed very light also around Orizaba, but within two weeks local infestations were found so that it was possible to make satisfactory shipments of coccinellid larvae which later reared out as the *Hyperaspis silvestrii.*

Collection and Shipping of *Hyperaspis* and *Curinus*

Soon after the middle of March the infestations of mealybugs at Orizaba had developed so that coccinellids could be obtained and the collecting and shipping of the beetles was begun and continued for a period of about six weeks. The mealybugs during this time fluctuated widely from week to week, appearing suddenly in small areas at times and then being quickly and completely cleared off by the coccinellids. Thus at times the coccinellids were obtained in good numbers without difficulty. On one occasion I found, half covered with vines, a small guava tree, two branches of which had been quite heavily infested but the tree was being very rapidly and efficiently cleaned by a swarm of the *Hyperaspis silvestrii.* I collected over 200 larvae of *silvestrii* from the two branches, a large part of them being full-grown, enough it would seem to account for the remaining mealybugs on this tree in a very short time. These larvae collected made up the most of one particular shipment to Honolulu.

In collecting colonies of *Hyperaspis* it soon became evident that more than one species were present, but no particular effort was made to segregate them in the shipments as they were of such similar habits that it seemed advisable to send them all to Hawaii. In subsequent rearings to the adult stage it appeared that *Hyperaspis silvestrii* had been much the most abundant species at the time the collections were made.

There was also a larger coccinellid sometimes found in the mealybug infestations although it appeared to be of very much less importance. This subsequently reared out as *Curinus coeruleus* (Muls.) and rather limited numbers were shipped to Honolulu.

At first, in collecting for shipment, eggs or small larvae were brought in from the field and fed on mealybugs until grown and then sent by express. Later on it seemed more desirable to wait until a few days before time to make a shipment and then to collect the larvae full-grown in the field. The method of preparing the larvae for shipment was exceedingly simple. Graniteware milk pails (usually one-quart size) were used, into which loose guava leaves and trash were placed. Some mealybugs were on the leaves although this was not essential as the larvae had about finished feeding and in any case there would not be enough mealybugs to last in such a container. Heavy muslin cloth was tied tightly over the top of the pails and these were then packed in especially made strong wooden boxes. About 50 *Hyperaspis* larvae were placed in each pail.

It was observed that some of the *Hyperaspis* larvae were themselves parasitized and that parasites might emerge from field-collected material. Mr. Fullaway later informed me that there was never any evidence that anything had escaped from the pails.

The total of 8 shipments of coccinellid material from Orizaba, March 27 to May 1, 1922, was: 720 *Hyperaspis silvestrii* larvae, 80 *Hyperaspis* sp. larvae, and 80 *Curinus coeruleus* larvae. From these there arrived alive in Honolulu 289 adult

Hyperaspis silvestrii, 27 *Hyperaspis* sp., and 37 *Curinus coeruleus. Hyperaspis silvestrii* and *Curinus coeruleus* were in part liberated and in part held in the insectary for rearing, where they bred successfully for distribution. They both became established and widespread in Hawaii, but whatever good they did at first was completely overshadowed by the work of the little parasite, *Pseudaphycus utilis,* which was sent to Honolulu at the same time from Orizaba.

Pseudaphycus utilis Timberlake and Its Introduction Into Hawaii

It soon became apparent at Orizaba that there were several species of mealybugs mixed up in the infestations on guava and avocado from which I was collecting the *Hyperaspis,* also, that there were more than one species of *Hyperaspis.* So far as the *Hyperaspis* was concerned this was not of such great importance since these coccinellids fed somewhat indiscriminately on all of the mealybugs.

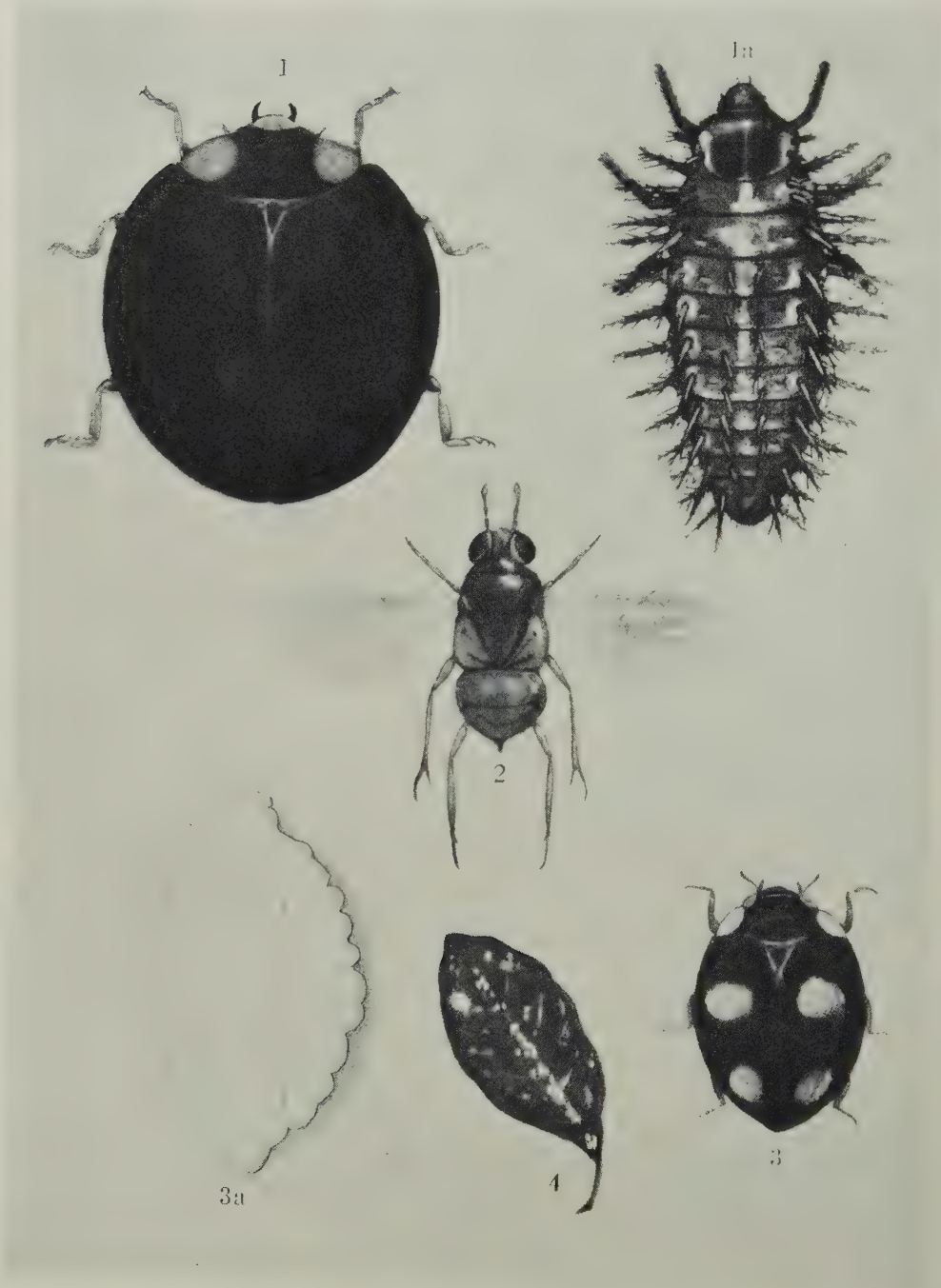
However, there were soon found to be several hymenopterous parasites attacking the several species of mealybugs and these in turn proved to be attacked by a number of hyperparasites comprising in all a somewhat complicated interrelationship. The last of the primary parasites to be noticed while I was working at Orizaba was the one which I referred to as a bright-yellow parasite on *Pseudococcus nipae,* and which was later identified as new and described by P. H. Timberlake as *Pseudaphycus utilis.**

Shipments of parasitized mealybugs were made in April 1922. They were mostly collected on the heavily infested tree from which the coccinellids were collected for shipment, adults of the bright-yellow parasite were observed and several caught. A few were reared out from a part of the material similar to that sent to Honolulu. Some of the material sent was from the scattering infestations previously mentioned and most of the mealybugs were found to contain parasite larvae if dissected.

From one lot of the parasitized material which was sent, Mr. Fullaway secured 23 females and 26 males of *Pseudaphycus utilis.* On the advice of Mr. Timberlake these were liberated directly in infestations of *Pseudococcus nipa*e in Honolulu without attempting to rear them. One of these localities of liberation was a fig tree in a yard adjoining the Experiment Station, H.S.P.A., on Keeaumoku St. From this tree three adult parasites were recovered early in October of the same year, and was the first indication of the parasite becoming established.

I left Orizaba early in May and was located for several weeks at Cordoba, Vera Cruz, about 25 miles distant from Orizaba and at a much lower elevation, about 2500 feet. At this time in the vicinity of Cordoba, *Pseudococcus nipae* was conspicuous by its absence, although there was a great abundance of the favorite host plants. I made no further shipments of enemies of *Pseudococcus nipae.* Never in the next few years spent in various sections of tropical Mexico did I observe *Pseudococcus nipae* as abundant as it was at times during the six-week period at Orizaba in March and April, 1922. At Cordoba and at El Potrero in Vera Cruz, at altitudes from 1800 to 2500 feet, *nipae* was usually present in small numbers if searched for on guava and on avocado, but not sufficiently abundant to be notice-

* Proceedings of the Hawaiian Entomological Society, 5: 323-326, Figs. 1-4, 1923.



Enemies of the avocado mealybug. (Courtesy of Board of Agriculture and Forestry.)

1. *Curinus coeruleus.* Adult beetle.
1a. *Curinus coeruleus.* Larva.
2. *Pseudaphycus utilis.* Parasite.
3. *Hyperaspis silvestrii.* Adult beetle.
3a. *Hyperaspis silvestrii.* Larva.
4. Leaf infested with mealybugs.

able. In no case did I find it abundant enough so that *Hyperaspis* could breed up to any extent. If carefully looked for at these lower elevations the *Pseudaphycus utilis* would be found parasitizing the *nipae*.

In view of its subsequent record in Hawaii, it would seem that *Pseudaphycus utilis* is the more important controlling factor at the lower elevations in tropical and subtropical Mexico, although I never would have thought so on the basis of observations made at Orizaba in the spring of 1922. From the standpoint of securing mealybug enemies for shipment it was fortunate that my first work was done in a particular locality where the control of *nipae* was somewhat irregular as was the case at Orizaba.

In about a year from the first recovery of *Pseudaphycus utilis* in Honolulu, the decline of *Pseudococcus nipae* began to attract attention, and by early 1924 it had practically disappeared on the island of Oahu where the first liberation of *Pseudaphycus utilis* had been made. In November 1924, I returned for a short time to the Islands and at that time it was still possible to find infestations on the islands of Maui and Hawaii, but the island of Oahu was entirely clean of *Pseudococcus nipae* and has remained so continuously since that time. In a very short time thereafter the infestations on the other islands of the group were cleaned off also. Ever since, the leaves of avocado remain clean, as do also the leaves of fig, mulberry, guava and other trees which were formerly always infested by *nipae*. It has been a most remarkable case, both as to rapidity of spread of the introduced parasite, and completeness of its work on the host insect, practically amounting to eradication. It seems reasonable to expect that under the conditions in Hawaii, *Pseudaphycus utilis* will continue alone to exert a complete control of the avocado mealybug.

Other Mealybug Enemies

In addition to *Pseudaphycus utilis* there were three other primary parasites in the mealybug infestations about Orizaba which were collected in some number and shipped to Honolulu.

Allotropa sp. (Platygasteridae). Mr. Fullaway reported that 475 females and 353 males of this species were reared out alive in Honolulu from material sent from Orizaba in March and April. They were released directly into the field.

Gyranusa, 2 species (Encyrtidae). Of these parasites 74 females and 16 males were reared out alive in Honolulu and released directly into the field.

None of these parasites appear to have become established in Hawaii, and I have always considered that their host was not *nipae*. There were several recognizable differences in the living mealybugs on the trees, and so far as I could determine at the time, my rearing of *Pseudaphycus utilis* was from *nipae* while the rearings of *Allotropa* were from what I took to be another species which I referred to as the buff mealybug. Oviposition was observed in the field by both the *Allotropa* and the *Pseudaphycus* in very young mealybugs, and even in the young stages the two mealybugs involved seemed to be distinct. However, specimens of what I called the buff mealybug, which were killed and sent for identification, were pronounced to be *Pseudococcus nipae*, as were also those which I considered to be the true *nipae*. The two species of *Gyranusa* were possibly also from still a third species of

mealybug, although in the limited time in which I was working on these there were many points which I did not determine definitely.

In addition to the coccinellids and the parasites mentioned there were also a number of insects found feeding in the mealybug infestations, which seemed to be of minor importance and no special effort was made to collect them. Among these was a scymnid, a syrphid *(Baccha)*, an agromyzid *(Leucopis)* and a hemerobiid. Caution was advised in the case of the hemerobiid, in a letter of July 13, since they were observed at times to attack the coccinellids as well as the mealybugs.

Sugar Prices

96° CENTRIFUGALS FOR THE PERIOD
DECEMBER 20, 1937 TO MARCH 15, 1938

Date	Per pound	Per ton	Remarks
Dec. 20, 1937....	3.25¢	$65.00	Cubas.
" 21.....	3.20	64.00	Cubas.
Jan. 7, 1938....	3.23	64.60	Cubas.
" 10.....	3.23	64.60	Philippines.
" 12.....	3.25	65.00	Cubas.
" 18.....	3.23	64.60	Cubas.
" 19.....	3.20	64.00	Philippines.
Feb. 1.....	3.17	63.40	Cubas, 3.18; Philippines, 3.16.
" 8.....	3.15	63.00	Philippines.
" 10.....	3.13	62.60	Puerto Ricos.
" 11.....	3.125	62.50	Philippines, 3.12; Puerto Ricos, 3.13.
" 14.....	3.13	62.60	Puerto Ricos.
" 16.....	3.17	63.40	Philippines.
" 21.....	3.15	63.00	Puerto Ricos; Philippines.
" 24.....	3.13	62.60	Philippines.
Mar. 1.....	3.15	63.00	Philippines.
" 3.....	3.10	62.00	Puerto Ricos.
" 7.....	3.065	61.30	Puerto Ricos, 3.07, 3.06.
" 10.....	3.07	61.40	Philippines.
" 11.....	3.085	61.70	Philippines, 3.10, 3.07.
" 14.....	3.0667	61.334	Cubas, 3.08; Puerto Ricos, 3.07; Philippines, 3.05.
" 15.....	3.035	60.70	Philippines, 3.04, 3.03.